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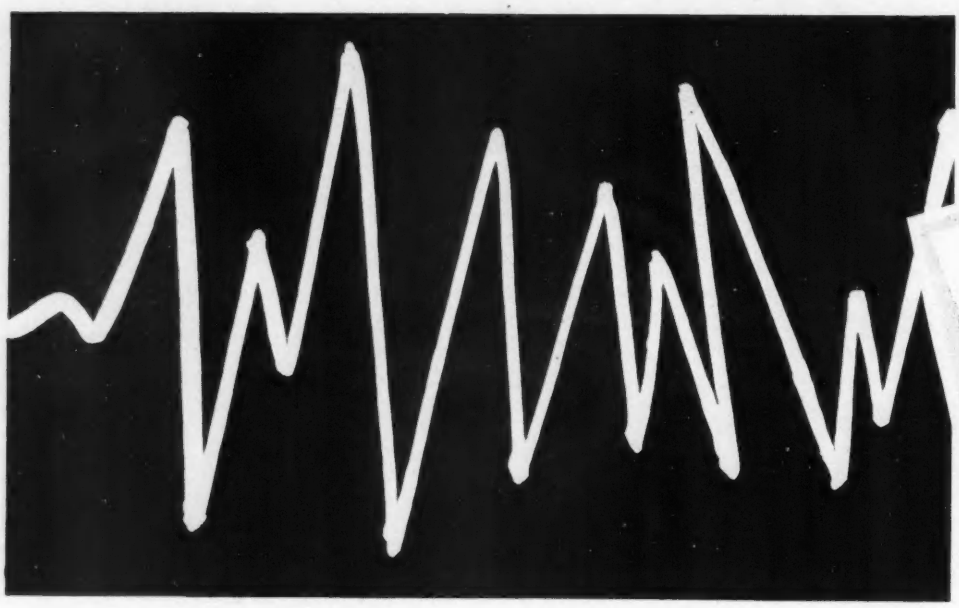

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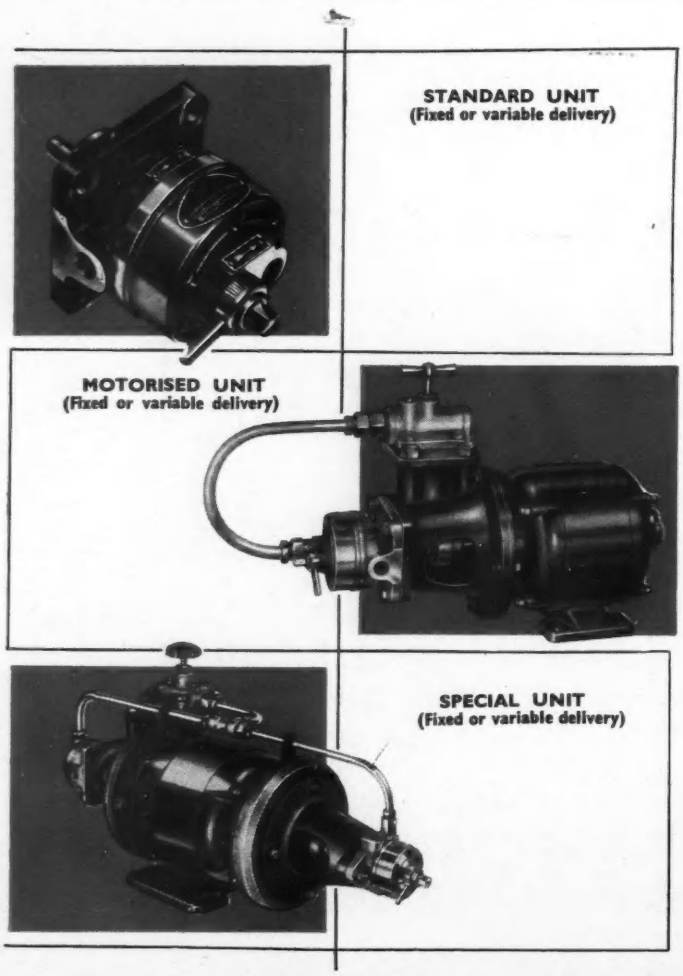

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THE ENGINEER

VOL. 202 No. 5257

OCTOBER 26, 1956

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REFLECTIONS ON THE MOTOR SHOW

Another Motor Show comes to its end this week, and it seems almost certain that, once more, by the end of this week about half a million people will have passed through the turnstiles at Earls Court to see the impressive assembly of motor-cars from all over the world. Attendance figures, of course, will be watched with interest by the organisers as well as by the exhibitors, and will be rightly interpreted as an indication of the demand for car ownership at home. There will also be another category of buyers, from overseas, who have come over here with the definite purpose of assessing the sales appeal of our latest models in comparison with those of our foreign competitors. Their verdict will play an important part in deciding the question whether or not the considerable drop in export sales which this country's industry has experienced in the last twelve months can be retarded or reversed.

This year's Motor Show is peculiarly interesting because, presumably, it reflects the initial response of the British motor industry to the challenge of foreign competition and represents the first stage in its campaign to recapture lost ground and expand its share of sales in free world markets. The importance of the show as a sales-stimulating display of the industry's best efforts is emphasised by the fact that, for the first time in the history of British motor exhibitions, the opening ceremony was performed by the Prime Minister. Sir Anthony Eden congratulated the organisers on having staged a colourful and impressive show which reflected the vigour and imagination of the industry. He admitted that part of the present difficulty in the home market was caused by the Government's battle with inflation, but regretted that he could not make any easy promises of relief. "Britain cannot go on exporting to competitive markets unless we offer as good value as our competitors or better. Above all, our costs must be stable, and that is what the Government's credit policy is trying to achieve." From those words it seems clear that no change in home market conditions can be expected in the immediate future, and that the industry has to concentrate its efforts upon either opening up new markets abroad or on regaining those which, though once considered firmly established, have been lost in the last few years to our Continental competitors. The reasons for the loss of markets and the apparently diminishing sales appeal of British cars compared with that of foreign makes have been frequently discussed in the technical press as well as in the city columns of our national newspapers. There is a wide measure of agreement that the adverse criticism we have to face in these markets is not so much directed against any specific mechanical deficiencies of British cars, as against the lack of technical innovations. The British motor-car—it is suggested—is primarily designed and built for British conditions, in particular for well-surfaced British roads and, therefore, it is less acceptable on other world markets than the vehicles made by German, French and Italian manufacturers.

The British motor industry, of course, is aware of any real shortcomings of its products; and prominent manufacturers have frequently stated that they actually welcome foreign competition as an eminently suitable means of stimulating efforts and furthering technical progress. In those circumstances it had been hoped that this year's Motor Show would be an impressive display of modern designs which, by the sheer weight of their technical ingenuity would challenge foreign competition in world markets. In that respect, however, it has proved disappointing, for the great majority of manufacturers have refrained from altering their models to any great extent and have concentrated on modifications, mainly of a kind that could be adopted without interfering with the flow of production. Yet, interestingly enough, in spite of the almost complete lack of any remarkable technical innovation by car manufacturers, a number of British cars have definitely increased their sales appeal. That result has been attained partly by improvements in styling and partly by the adoption of such useful accessories as automatic transmissions and devices for facilitating the gear-change operation. For the purpose of stimulating sales at home and abroad it is immaterial whether or not these components have been devised and built by the motor firms themselves or by vigorous and inventive makers of accessories. The fact that such components have been adopted, at least as optional extras, should be entered on the credit side of the industry's balance sheet. Indeed, our manufacturers deserve to be congratulated on their courage in fitting hydraulic transmissions in cars powered by engines of comparatively small cylinder capacity. Should the results appeal to users, few of whom will be engineers capable of a critical approval of their technical merits, then the industry will have gained a great, though probably temporary, advantage over its Continental competitors who, so far, have been either reluctant or unsuccessful in their experiments. Similar considerations apply to the use of automatically operated clutches

in which field British manufacturers have a clear lead. But whether or not recent modifications to British popular smaller cars will be sufficient to counteract the impact in export markets of such unconventional Continental cars as the V.W., the Renault "Duchesse," the Fiat "600" and "Multipla," remains to be seen. In that particular field efforts have not been very far-reaching. Our industry, lacking adventurous spirit, has preferred the more comfortable path of "evolutionary development" to the bolder ventures of Continental constructors. Such an attitude of mind may appear appropriate in times of prosperity. For then there is no urgent need to change the design of some proven saleable model. But in a world of ever-changing ideas and one dominated by fierce international competition, it is not enough to keep merely just abreast of engineering progress. It is essential to be ahead of current ideas. Considered from this point of view, we doubt whether our 1957 models, as a whole, really represent the best possible effort the British motor industry can make; more probably—we certainly hope so—they can be regarded as products of a transitory phase during which our manufacturers will develop designs which, in their appearance as well as in their technical specifications, should prove more acceptable in all world markets. That, if prosperity is to return, such a reorientation inside the British motor industry will have to take place is certain; the only question is how soon it will happen. We feel moderately optimistic. Technical progress can be delayed by conservatism or prejudice only in a self-contained community. In a highly competitive world the pressure of economic reality must in the end override preconceived ideas.

A PLEA FOR A NAVAL BUILDING PROGRAMME

Among the new warships authorised in the 1956–57 United States naval budget of 10,000 million dollars are another giant carrier of 60,000 tons, a nuclear powered guided missile cruiser and twelve destroyers or frigate-type vessels armed with guided missiles. Approval has also been given for the procurement of the necessary material for nuclear power plants for another carrier and another guided missile vessel. It is evident that the Americans are hesitating before embarking on a wholesale change-over to nuclear propulsion for surface warships. But the number of ships authorised with a guided missile armament—several existing ships are also being equipped to fire these missiles—leaves no doubt that the United States Navy is well satisfied with the two kinds of anti-aircraft guided missile now in service.

Apart from winged missiles of the V-1 type—which have few advantages over strike aircraft—there are as yet no ship-to-ship guided missiles available. Indeed, they will not be an essential requirement as long as strike aircraft continue to be effective. The new giant carrier—there are now six of these ships building or authorised—is evidence that the Americans still have in mind the possibility of an unforeseen surprise attack and that they are determined to preserve their retaliatory power. Having built up a massive and adequate retaliatory force of long-range bombers—at well-defended and widely dispersed bases in the homeland—and of medium range B-47 bombers stationed in Britain and other countries nearer Russia, their one remaining anxiety is that it should be available if and when required. It is largely for this reason that these giant carriers—each costing about £70,000,000—are being built. They will not only supplement the bombers of the United States Strategic Air Force, but will provide an effective replacement if necessary.

The British Government, on the other hand, now appears to have more faith than the United States Government in the efficacy of the deterrent. The 1955 Defence White Paper dealt at considerable length with the possibility of the deterrent failing; "We must have the will to survive and the power to ensure victory." A year later, there was a marked change of emphasis. The deterrent now enables us to regard the cold and limited war as the main threat to our freedom and security. Though we are adding our mite to the thousands of bombers of the United States Strategic Force, it is entirely due to the immense American effort that we are able to frame our defence policy on this basis. Surely then it is our duty to co-ordinate our defence effort with the United States by providing the type of forces which would be of particular assistance to her in a global war. It would entail only two additional commitments which are well within our financial resources. First, that Britain—and the B-47 bombers operating from Britain—should be given the best possible defences; secondly, that the Royal Navy should have the ships required to safeguard her sea communications without having to rely—as the Government is content to do—on assistance from the United States Navy. We can find the money without difficulty by reducing the number of V-bombers we are now building purely for the sake of prestige. Indeed, it is far from clear why Britain, which has become great through sea power, should be content to rely on the navies of other N.A.T.O. Powers to assist the Royal Navy in its vital task of safeguarding our imports, when it is able to find money to add to an air deterrent which is already adequate. Nor is it consistent with the Government's view of the main threat to this country. Though not wholly the result of the cold war, the Suez Canal crisis is an example of the kind of emergency we may be faced with in the future—a local war to defend our vital interests, without the assistance of our great ally. It is a clear indication that we cannot afford to neglect the Navy and Army in order to build up forces which are not essential and which would only be used in the unlikely event of a global war. For the Royal Navy must have modern carriers equipped with modern aircraft and cruisers armed with modern anti-aircraft defences if it is to co-operate effectively with troops ashore. If it is to remain an effective force—whether in peace or for any form of war—a building programme of large ships should be started immediately the "Girdle Ness," recently commissioned, has completed her trials of the ship-to-air guided missile which this country has at last managed to design and develop. One prototype vessel will not be sufficient. The minimum and urgent requirement is the provision in next year's Navy Estimates of a squadron of four ships such as cruisers.

The Engineer
100 Years Ago
(OCTOBER 24, 1856)

"REPORTS ON COAL MINES"

"The Reports of the Government Inspectors of Coal Mines for the half year ending December, 1855, were published last week.... Some of the reports are for half years, others for years, others for a few odd months.... The casualties from the bursting of steam boilers, though making but a small fraction of the whole number, are sufficiently important and interesting to deserve a more extended notice. Four boiler explosions are reported....

"The limits of this article do not admit of our prosecuting an analysis of the reports in all their bearings: our present purpose is to comment upon the causes of boiler explosions reported by the inspectors, and our remarks may also be taken as a useful commentary on our opinions, already freely expressed, of the general system of steam generation in this country. And, in the first place, the wretched system of external firing, on brick beds with external flues, is illustrated forcibly by the explosion at Stavely Colliery, where the boiler had been worn down to one-eighth of an inch thick at one part. A striking coincidence may be remarked in the circumstances of this explosion, and those of the recent explosions near Bury—in both instances the boiler plates were worn to an extreme thinness at particular localities; in both cases cobbling patches were put on; and in both cases an explosion quickly ensued. We may add that, in both cases, the boilers were most unwarrantably placed in charge of ignorant men, not paid for their responsibility; and, in both cases, the really culpable parties were the proprietors.... The evidence on steam-boilers goes satisfactorily to show—what we have repeatedly dwelt upon—that the multitubular-flue boiler is the only universal type, applicable in all situations, safe in all situations, compact and powerful....

"These reports of coal-mine inspectors are suggestive of much useful reflection on the more immediate business of the mines. ... Assuredly it may be said in earnest, that a man should make his will before getting into one of these pits; for he may be discharged any moment, more dead than alive, at an inconveniently short notice, by one of those horrible and still frequent subterranean explosions."

A Seven Day Journal

Institution of Mechanical Engineers' Annual Dinner

AT the annual dinner of the Institution of Mechanical Engineers on Thursday, October 18th, General Sir Brian Robertson, chairman of the British Transport Commission, proposed the toast of "The Institution." He remarked that in the past the railways of this country had failed to afford the opportunities that engineers wanted. Engineers wanted opportunities for practical testing. But before the war there was too much economising and after the war there was restriction of capital expenditure. But now, under the modernisation plan, immense opportunities had been created. British Railways needed men versed in the technical skills of diesel traction, signalling, &c., and were ready to pay for the best engineers. In a reference to the supply of diesel locomotives under the modernisation plan he said that though British Railways appreciated the importance of the export market they could not afford to accept low priority on the delivery list. They expected to be treated as potentially big customers. As much as possible was being done to provide suitable maintenance facilities ; but not as much as manufacturers would like. The equipment provided should therefore be particularly reliable. In reply, Mr. Crowe, president of the Institution, remarked, a little dryly, that in the past the railways had been large potential customers, but that they had remained potential customers ! Under British Railways, manufacturers now hoped to get a fair share of orders. Professor Saunders, vice-president of the Institution, then proposed the toast of "Our Guests." In reply, Dr. Richard Hearn said that Canada looked largely to the United Kingdom for advancements in atomic energy. In the province of Ontario, from which he came, water power resources would be fully developed within ten years and already they were turning to thermal power. There was neither coal nor oil in Ontario. But there was uranium.

Consulting Engineers and Nuclear Power Development

COINCIDENT with the opening of Calder Hall last week, the Association of Consulting Engineers issued a memorandum directing attention to the important part being played by consulting engineers in the development of nuclear power. This document says that members of the Association realised at a very early stage the future importance of nuclear power and for some years past have been equipping themselves with knowledge and experience. In doing so they have had in mind not merely the part they might take in the development of nuclear power in Great Britain, but the equally important part they might be called upon to play in the development of this form of power overseas, and especially in the Commonwealth. As a spearhead of Great Britain's export drive, the memorandum adds, it is essential that consulting engineers be fully equipped with the most up-to-date knowledge and experience in the nuclear energy, as in other fields. The role of consulting engineers, the memorandum continues, has been appreciated by the United Kingdom Atomic Energy Authority, which has granted facilities to members of the Association to obtain training and experience at its various establishments. Several members of the Association of Consulting Engineers have, therefore, had staff attached to the Authority's establishments for some years past. The memorandum also makes reference to the various services now being rendered by consulting engineers in projects which the United Kingdom Atomic Energy Authority has in hand. It ends by saying that Great Britain is in the forefront of the development of nuclear energy for the production of electric power. Members of the Association of Consulting Engineers, with the experience they are gaining in this important new field, are in an unrivalled position to assist Great Britain to maintain that position and to develop the export market.

Conserving Water Resources

THE second of the Institution of Civil Engineers' series of lectures on the conservation of natural resources was given on October 18th by Mr. G. M. Binnie ; he spoke on "The Control, Storage and Use of Water." The lecture was comprehensive in its scope and reviewed all the major uses of surface and underground water, and problems in utilisation and control such as the prediction and control of floods and underground storage. Mr. Binnie considered that one of the major problems of water conservation was that the gross storage of a reservoir was generally a dwindling asset, because of sedimentation. There were no clear-cut remedies, he asserted, but he gave one instance of a reservoir in Algeria, where the so-called method of density currents, which depends on a temperature difference between the reservoir water and the water flowing into the reservoir, was to be used. Water would be introduced from upstream in "flushes" in such a manner as to encourage deposition of clay and silt near the dam, where it would subsequently be passed on down the river. The reservoir would keep 80 per cent of its original storage capacity indefinitely, if operated in this manner, he said ; otherwise 50 per cent of its capacity would be lost in about forty years. Mr. Binnie subsequently gave some details of the large scheme for water conservation and irrigation in Iraq, centered on the lesser Zab River, and involving construction of the Dokan dam. He emphasised the difficulties which had to be surmounted to achieve success and a long life in an irrigation project. Soil and land surveys and classifications were essential ; such surveys had shown that of the 1,000,000 acres of land potentially available for irrigation in the scheme in Iraq, a large proportion was unsuitable ; of the remaining land, considerable areas would need treatment by leaching, or by adding gypsum, before they could be brought into cultivation, and the whole irrigated area needed an efficient drainage system.

Lloyd's Shipbuilding Returns

LLOYD'S REGISTER has issued its shipbuilding returns for the quarter ended September 30th. Work in hand comprised 333 steamships and motorships of 2,077,976 tons, compared with the average of 2,150,000 tons over the last three years. During the quarter 60 ships of 289,821 tons were commenced and 54 ships of 283,992 tons were launched, while 61 ships of 244,786 tons were completed. Of the tonnage under construction 73 ships of 486,286 tons or 23·4 per cent were for registration abroad, compared with the peak figure of 825,745 tons or 40·4 per cent in 1950. Some 58 oil tankers of 842,564 tons were under construction and amounted to 40·5 per cent of the total tonnage being built. Orders outstanding for ships for which only plans have been approved or material ordered increased by 212,336 tons over the last quarter to 2,329,298 tons, the rise corresponding with the percentage of oil tanker orders which now represent 62·2 per cent. Abroad, the work in hand totalled 1168 ships of 5,371,334 tons, an increase of 176,462 tons over the previous quarter, while ships commenced, launched and completed amounted to 346 ships of 1,479,305 tons, 395 ships of 1,309,987 tons and 371 ships of 1,300,588 tons respectively. Ships for registration elsewhere than in the country of building had a total tonnage of 2,643,863 tons, or 49·2 per cent of the total, and included 164,727 tons for Great Britain and Northern Ireland. Oil tankers building abroad totalled 161 ships of 2,150,637 tons, representing 40 per cent of the total tonnage. Throughout the world 1501 steamships and motorships of 7,449,310 tons gross were under construction, of which 27·9 per cent were being built in Great Britain and Northern Ireland. Oil tankers totalled 219 ships of 2,993,201 tons, representing 40·2 per cent of the total tonnage under construction. Out of the world total, 3,130,149 tons were for export, of which the share of Great Britain and Northern Ireland was 15·5 per cent. Grouped according to size, the totals included 165 ships of 6000 to 8000 tons, 131 ships of 8000 to 10,000 tons, 120 ships of 10,000 to 15,000 tons, 27 ships of 15,000 to 20,000 tons, 62 ships of 20,000 to 25,000 tons, 18 ships of 25,000 to 30,000 tons, and 7 ships of 30,000 to 36,000 tons each. Of the total world construction, 4,518,550 tons, amounting to 60·7 per cent, were under the inspection of Lloyd's Register.

Philip Vassar Hunter, C.B.E.

As we were going to press we learned with regret that Mr. Philip Vassar Hunter died on October 22nd at Springhurst, Shirley Church Road, Addington. He was a past president, and an honorary member, of the Institution of Electrical Engineers, and a director of British Insulated Callender's Cables, Ltd. During the early part of his career he worked for fifteen years with Messrs. Merz and McLellan and, as head of their electrical department, he was responsible for the design of power stations on the north-east coast and for railway electrification, particularly in South America. During the first world war he served as engineer to the experimental and research section of the Anti-submarine Division of Naval Staff and he helped to develop the Asdic gear and other methods of submarine detection. On leaving the Admiralty in 1919 he joined Callender's Cable and Construction Company as chief engineer and joint manager. Since then he has been associated with many important developments in electrical transmission, with particular reference to high voltage power cables. For example, he evolved the split-conductor and four-conductor methods of cable protection and he was closely concerned with the more recent developments in cables for very high voltages, making use of inert gas under pressure. During the second world war he again assisted the Admiralty and he was responsible for the development of the buoyant cable which was used for minesweeping.

A.C. and D.C. Conduction Pumps for Liquid Metals

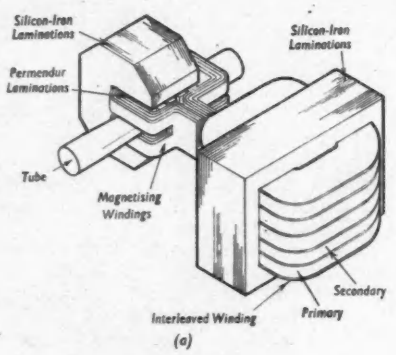
By L. R. BLAKE, Ph.D., B.Sc., A.M.I.E.E.*

No. II—(*Concluded from page 544, October 19th*)

An examination is made and the chief design features established of the d.c. conduction pump and of the mains-frequency and low-frequency a.c. conduction pump, including types with combined low-voltage transformer. Special consideration is given to their behaviour at high output powers with liquids such as bismuth. Performance figures of typical designs are given and the relative merits of the different types of conduction pump are outlined. It is suggested that the low-frequency a.c. conduction pump is a useful alternative to the d.c. conduction pump and homopolar generator.

Series-Excited, Single-Turn, Compensated, Conduction Pump

In Fig. 7 is shown an a.c. conduction pump supplied from a low-voltage transformer; the pump has a series-excited, single-turn magnetising winding and is compensated for "armature reaction." Details of the winding are given in the sectioned drawing of Fig. 7 (*b*). The current route in the pump is as follows. The current enters at, say, the left-hand busbar, makes a half-turn clockwise



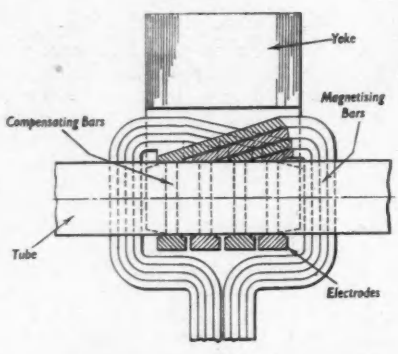


Fig. 7—(*a*) Conduction pump and supply transformer. (*b*) Section through tube of a.c. conduction pump

round the pole, then passes through compensating bars set in the pole face. The bars join the tube wall on the near side and the current completes the circuit through the liquid metal to electrodes on the far side, which connect to the right-hand side of the magnetising loop.

The winding can take other forms, but all are basically similar. For example, if the winding is joined together at the two input busbars and as close to the pole face as possible, the winding can be cut at any other point in the circuit and the busbars joined to the ends. Various physical arrangements follow simply upon where the join is made. Notice that the winding is separated into four parallel paths, insulated from each other. This is obviously essential if large eddy losses in the compensating winding and flux screening is to be avoided.

The arrangement of Fig. 7 is one of the simplest to analyse and it is also in fact one of the most efficient forms of a.c. conduction pump. The equivalent circuit of the pump is shown in Fig. 8.

The dominant terms in the equivalent circuit which control the power factor are r and $x_p+x_l=x$. Expressions for these terms are approximately

$$r=\frac{\rho b}{ac} \text{ and } x=2\pi f\frac{1\cdot257}{10^8}k_L\frac{bc}{d}$$

where k_L is the leakage factor. The power factor of the pump is therefore

$$\cos\phi=\frac{R}{\sqrt{r^2+x^2}}\simeq\frac{r}{x}=\frac{6\cdot9.10^8\rho}{fc^2}$$

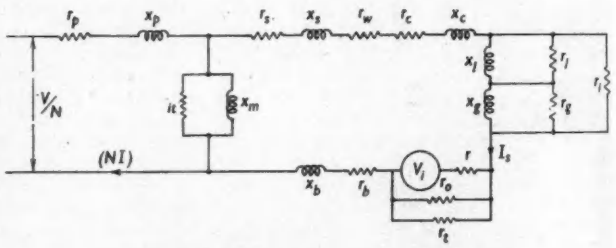
writing $d=1\cdot2a$ and $k_L=2\cdot2$.

Thus to a first order the power factor falls as the inverse square of a linear dimension of the pump. If at 50 c/s a valueof r/x of 0·3 is considered as the lowest limit acceptable, and at 5 c/s a value of 0·6 is assumed, then the upper limit of the value for c can be deduced. Assuming a reasonable pump geometry, say, $a:b:c=1:2:4$, and reasonable values for the liquid velocity, the upper limit of pump flow can be established. Taking sodium and bismuth as two typical liquids, the upper limits of flow work out approximately as in Table I, below.

There is a further limit to the size of the a.c. conduction pump set by current penetration effects in copper itself. If d_{pc} is the depth of penetration in copper given by $d_{pc}=(12\cdot7\times10^6\rho_c/f)^{\frac{1}{2}}$, then the total magnetising section should not be allowed to exceed greatly the dimensions $2d_{pc}\times2d_{pc}=4d_{pc}^2$, and in particular the height of the compensating bars should not greatly exceed d_{pc}. Assuming a copper temperature of 400 deg. Cent, $\rho_c=4\cdot27$ microhm-cm then $d_{pc}=7\cdot36/f^{\frac{1}{2}}$; thus at 50 c/s, $d_{pc}=1\cdot04$cm and at 5 c/s $d_{pc}=3\cdot3$cm. With current densities of about 1kA/cm² this implies that the maximum current should not exceed 4000A at 50 c/s and 40,000A at 5 c/s. This restriction on the current limits the maximum pump pressure at which a pump can be operated and it also limits the pump flow and pump output as well.

Table I—*Maximum Values of Pump Flow for Sodium and Bismuth at 5 c/s and 50 c/s*

	Sodium		Bismuth	
Frequency	5	50	5	50 c/s
Flow	60	6	350	50 g.p.m.



r_p, x_p = resistance, leakage reactance of transformer primary winding.
r_s, x_s = resistance, leakage reactance of transformer secondary winding.
x_m = transformer magnetising reactance.
r_{ti} = transformer iron loss resistance.
r_w = resistance of series magnetising winding of pump.
r_c, x_c = resistance, reactance of compensating winding of pump.
x_l, x_g = reactance associated with pump leakage and gap fluxes.
r_l, r_g = eddy current loss equivalent resistances due to leakage flux and gap flux respectively.
r_i = pump iron loss resistance.
r = resistance of liquid associated with useful component I of electrode current I_s.
r_o = resistance of liquid associated with useless component I_o of I_s.
r_t = resistance between electrodes of tube wall.
$V_i = Hbv.10^{-8}$ = induced voltage due to fluid motion in field.
r_b, x_b = resistance, reactance of transformer pump connections.

Fig. 8—Useful equivalent circuit of a.c. conduction pump

Relatively simple considerations indicate the optimum operating frequency of the a.c. conduction pump. The advantages of using the normal power supply encourages mains frequency pumps to be used up to the maximum possible size, where flux penetration effects are limiting and the power factor is falling away badly. Beyond this size, indicated approximately in Table I, a low-frequency generator is unavoidable.

As the frequency of operation of the pump is lowered from 50 c/s, at first there is little change in the size of the supply transformer despite the reduction of frequency, since it is serving an essentially inductive load, so the kVA required falls in proportion to the frequency. When the frequency is lowered to the point where the power factor is about 0·7 the reduction of kVA with frequency is no longer so marked and consequently, as the frequency is lowered further, the transformer size increases at a higher rate than the reduction in size of the low-frequency generator. There is evidently then an optimum value of frequency for any pump where the total rating or cost of the low-frequency generator and supply transformer is a minimum.

The series-excited, single-turn, compensated a.c. conduction pump, with separate low-voltage supply transformer, shown in Fig. 7, appears somewhat awkward, but it is difficult to improve upon, as it leads to a high power factor, a high efficiency and low pump weight. The transformer is shown here approximately to scale with respect to the pump; it has a shell type or double-loop magnetic circuit which is generally the best arrangement, for it gives a somewhat lower core weight than a single loop or core type magnetic circuit, and the additional leakage flux in this instance is negligibly small. An interleaved primary and secondary winding is shown to keep the leakage reactance low, but this may demand special cooling of the secondary copper, particularly at high liquid-metal temperature.

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A.C. Pump with Combined Transformer

It is tempting to try to combine the iron circuits of the transformer and pump. This can be done in a number of ways : four of many possible methods are shown in Fig. 9 ; Fig. 9(*a*) is substantially similar to types mentioned in references [6] and [7] ; Fig. 9(*b*) shows an arrangement employed by the author. Both (*a*) and (*b*) have serious disadvantages which render them inferior to the arrangement of Fig. 7, though they are useful in small sizes. Pump (*b*) is a single turn compensated pump and is therefore useful in rather larger sizes than pump (*a*), which is uncompensated ; they are, however, essentially competitive arrangements and the superiority of one over another is best judged on performance.

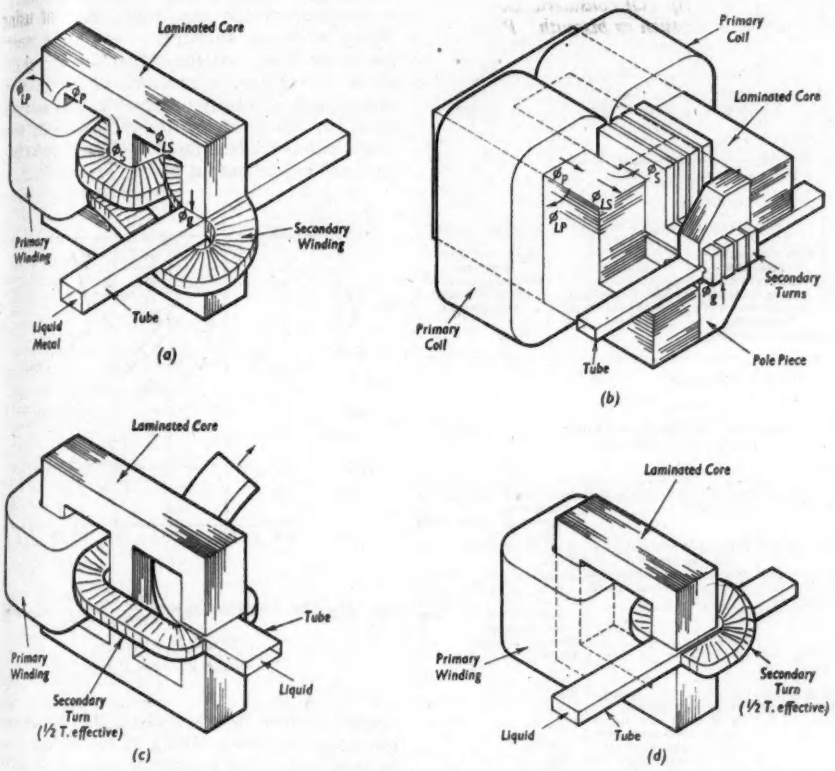


Fig. 9—Four kinds of a.c. conduction pumps with combined transformer

Fig. 9(*c*) shows a pump where the tube circuit takes a rather complicated path which cannot be contained in one plane ; this pump is a logical extension of pumps (*a*) and (*b*), where the secondary winding and magnetic circuit respectively are not co-planar. Fig. 9(*d*) is a further arrangement called by Watt the "leakage reactance pump"[6] which avoids the use of a three-limbed core, though at the expense of performance, and depends on leakage reactance of the winding to ensure that the field H and the liquid current I are in phase. Other pumps include two-phase and three-phase arrangements, annular pumps in which the magnetising current is kept within the liquid[8] and spiral and helical forms. In certain circumstances such pumps have advantages, but usually the pumps of Figs. 7, 9(*a*) and 9(*b*) are more useful. For example, induction pumps are useful in handling liquid containing impurities which build up on the tube wall and prevent conduction through it, or where it is desirable to avoid the use of a metallic containing tube.

The main disadvantage of the pumps with combined transformer, as typified by the arrangements of Figs. 9(*a*) and (*b*), is that the magnetising winding is wound around a limb of the core remote from the gap, so the leakage factor is probably twice as large as if the winding surrounded the pole pieces close to the gap. Moreover, the primary winding is on still another limb, so the primary leakage reactance too is excessive. The arrangement of Fig. 9(*a*) suffers from having no compensating winding, and the solid copper secondary circuit leads to excessive eddy-current losses both in the copper and in the liquid. Moreover, with this arrangement it is difficult to employ a ratio of c/b as high as desirable and this also reduces efficiency and has a tendency to make the pump pressure low. Fig. 9(*a*) is intended only as an example of the type, but the one-and-a-half-turn magnetising winding is unlikely to be the best arrangement : a half-turn winding, as in Figs. 9(*c*) and (*d*) would probably be better.

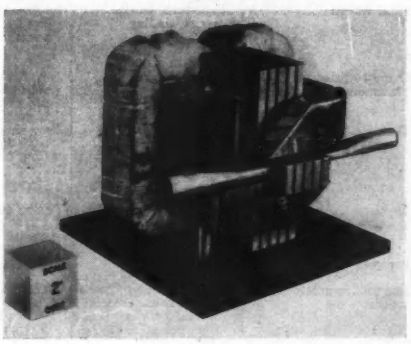
TABLE II—*Design and Performance Details of A.C. Conduction Pump with Combined Transformer*

Type of pump as Figs. 9(*b*) and 10(*a*). Liquid mercury at 100 deg. Cent.	
Tube bore	¾in nominal
Tube section	0·34in × 0·94in
Tube wall	0·022in
Primary copper area	4·0in²
Primary core area	7·2in²
Secondary copper area	2·1in²
Nominal primary ampere-turns	4800
Input apparent power	5·2kVA
Input power	1·65kW
Power factor	0·32
Standstill head	17 lb/in²
Maximum output	11 lb/in² at 14 gal./min = 108W
Maximum efficiency	6·5 per cent
Output characteristic, Fig. 10(*b*) :	
Total weight	87 lb
Dimensions	8¾in × 9in × 7in

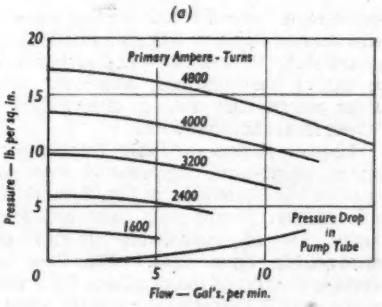
The arrangement of Fig. 9(*b*) avoids many of the drawbacks of the Fig. 9(*a*) type, and it has the merit of being simple to manufacture, so that, although its leakage factor is high, it is useful in small sizes. Fig. 10(*a*) shows a prototype pump of this kind, with a nominal output of 14 g.p.m., 11 lb per square inch, with mercury or bismuth ; both these figures can be increased by 50 per cent by forced cooling of the winding. The output characteristic is given in Fig. 10(*b*), and the vector diagram is shown in Fig. 10(*c*). Details of its design and performance with mercury at 100 deg. Cent. are given in Table II, though modifications are to be made which it is believed will improve the results. The performance with sodium, too, would be appreciably better than with mercury.

Comparison of Designs of 50 c/s, Low-Frequency and D.C. Pumps

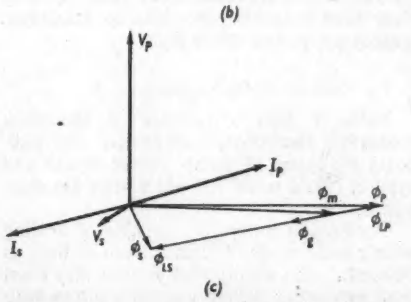
It has already been suggested that the efficiency and power factor of the a.c. conduction pump begins to fall off rapidly above a certain critical size, which depends on the liquid and the frequency. A better idea of how different pumps and their auxiliaries compare in performance, size and cost, can be given by a comparison of detailed designs. Table III summarises the relevant design details, and Table IV the relative merits of different arrangements. The first three pumps of Table III are designed for a duty of 60 g.p.m., 40 lb per square inch, which is near the upper limit in size for a 50 c/s pump ; the 50 c/s pump is compared with a 15 c/s and a d.c. pump. A comparison is also made between a 5 c/s and a d.c. pump at a duty of 250 g.p.m., 75 lb per square inch, which is near the upper limit for 5 c/s operation. It must be emphasised that these pumps represent only very approximately the upper limits in output power : the values indicated could easily be exceeded many times if,



(*a*)



(*b*)



(*c*)

Fig. 10—(*a*) Prototype a.c. conduction pump with combined transformer (normal output : 14 g.p.m., 11 lb per square inch with mercury) ; (*b*) performance characteristics of pump ; (*c*) vector diagram of pump

TABLE III—*Comparison of 50 c/s, 5 c/s and D.C. Conduction Pumps*

Bismuth at 400 deg. Cent. Tube wall, 85 microhm-cm resistivity at 400 deg. Cent.

Power supply	50 c/s	15 c/s	D.C.	5 c/s	D.C.
Output :					
Flow, gallons per minute		60		250	
Pressure, pounds per square inch		40		75	
Power, kilowatts		1·25		9·8	
Input :					
Voltage, volts	3·54	1·4	0·89	2·6	1·1
Current, kiloamps.	11·6	11·6	8·6*	40	39
Power :					
Kilowatts	12·3	11·4	7·7	61	42
Kilovolt-amperes	41	16·5	—	101	—
Power factor	0·30	0·69	—	0·60	—
Efficiency :					
Pump only, per cent	12	13	16	20	23
Including transformer, per cent	10	11	—	16	—
Design details :					
Liquid velocity, feet per second	18	18	18	24	24
Tube dimensions, inches	0·61×0·21	0·61×0·21	0·61×0·21	1·4×2·8	1·4×2·8
Wall thickness, inches	0·032	0·032	0·028	0·064	0·064
Peak field in gap, kilogauss	9·7	9·7	10·6	15·2	10·6
Weight :					
Pump, pounds	90	85	100	1200	800
Transformer, pounds	260	380	—	2600	—
Correction capacitor, pounds	300	—	—	—	—
Dimensions :					
Pump, inches	9×8×8	9×8×8	9×9×8	20×16×11	14×15×14
Transformer	10×14×13	11×16×15	—	18×28×25	—
Other auxiliaries	Voltage-regulating transformer	Motor/l.f. frequency changer	Motor/homopolar-generator	Motor/l.f. generator	Motor/homopolar-generator
Relative total cost	—	Not much greater than 50 c/s arrangement	Shows promise of being cheapest arrangement when homopolar generator developed	Use of conventional equipment keeps cost low at moment	Shows promise of being cheapest arrangement

* Uses two magnetising turns. Other pumps have one.

TABLE IV—*Relative Merits of 50 c/s, 5 c/s and D.C. Conduction Pumps*

Form of supply	50 c/s A.C.	5 c/s A.C.	D.C.	D.C.
Auxiliaries	Induction regulator or variable tap auto-transformer. P.F. correction capacitor	A.C. motor and l.f. generator	Motor and homopolar generator	Induction regulator or alternative and conventional metal rectifier
Flow control	Voltage regulator position	Control of field of l.f. generator	Control of field of homopolar generator	Voltage regulator position
Field system	Single-turn or half-turn series winding	Single-turn series winding : possibly two turns in small pumps	One turn in large pumps up to 3–5 turns in small pumps	Tendency to employ more turns than with homopolar generator arrangement to keep current lower
Overall efficiency	Usually lowest	Next highest	Highest	Possibly lowest
Maximum pump output	About 100 g.p.m.	About 500 g.p.m., but higher at lower frequency	Very large	Large
Cost	Usually cheapest	Becoming comparable with 50 c/s near upper limit of output	Usually more expensive than a.c. pumps, but this need not necessarily remain true when homopolar generators are an established line	Most expensive
Layout	Pump and transformer adjacent. Correction capacitor near, regulator remote	Pump and transformer adjacent. Motor-generator remote	Pump, homopolar generator and motor adjacent	Pump and rectfier adjacent
Pump size	Pump small	Similar to 50 c/s pump	Could be smaller than a.c. pump, but generally same size for better efficiency and low current	
Size of complete equipment	Capacitor and transformers each usually several times larger than pump	Machines much larger than pump, overall size somewhat larger than 50 c/s arrangement	Machines larger than pump ; this arrangement normally gives smallest overall size	Rectifiers very large in comparison with pump. Complete equipment very bulky

for example, special forced cooling measures were taken ; thus, a 500 g.p.m., 100 lb per square inch, 5 c/s pump would certainly not be out of the question. Moreover, much larger pumps than this are quite feasible at a lower frequency than 5 c/s.

The a.c. pumps in Table III are series excited, single-turn, compensated types with separate transformer as in Fig. 7, since it is believed that pumps with combined transformer are of appreciably inferior performance in large sizes. The flow and pressure conditions indicated are for a point on the output characteristic a little lower in flow than that corresponding to maximum output power and efficiency.

CONCLUSIONS

Table V lists a number of the most important electromagnetic pumps and indicates the range of pump output power and type of liquid metal for which they are most suited.

Conduction pumps are capable of dealing with a wide range of liquids from sodium to bismuth. At small output powers they excel over any other electromagnetic pump with any fluid : with sodium at higher output levels they are generally inferior to induction pumps ; with bismuth the conduction pump is generally most suitable at any power level. Conduction pumps have the advantage, due to their low operating voltage level, of needing little electrical insulation and this renders them specially suitable for use with high-temperature radioactive liquids.

The a.c. conduction pump with combined transformer, operating at mains frequency, is most convenient and inexpensive in sizes up to about 20 g.p.m., 20 lb per square inch, and is appreciably cheaper than the d.c. conduction pump mainly because it needs no special electrical supplies. Between 20 and 100 g.p.m. the value of combining pump and transformer appears more questionable, but the mains frequency a.c. conduction pump with separate transformer is effective over this range. Pump power factor falls as size is increased within this range, but the efficiency increases, showing a maximum near the upper limit. At the higher flow level of about 100 g.p.m. a pressure of 50 lb per square inch is readily achievable, but at this point the power factor and efficiency of the 50 c/s pump are beginning to fall off rapidly. At a still higher output power, low-frequency

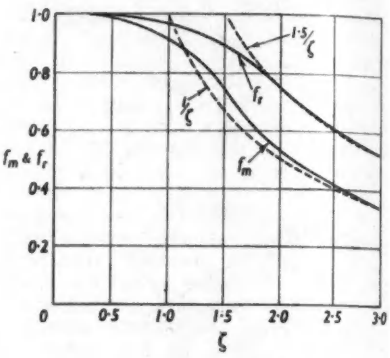


Fig. 11—The functions $f_m = \dfrac{\cosh 2\zeta - \cos 2\zeta}{\zeta(\sinh 2\zeta + \sin 2\zeta)}$ and $f_r = \dfrac{1·5(\sinh 2\zeta - \sin 2\zeta)}{\zeta(\cosh 2\zeta - \cos 2\zeta)}$

operation must be resorted to, the optimum operating frequency falling as the pump size is increased. This avoids the current supply problems of the d.c. pump, for which a large and expensive low-voltage rectifier of conventional type is necessary, or a homopolar generator with liquid metal brushes, a preferable alternative, though, at this stage, not without its difficulties.

Low-frequency a.c. operation has a basic advantage over a d.c. pump with homopolar generator set, for the motor generator set can be located remote from the pump and transformer, so that maintenance of the rotating machine is made easy and alternative supplies can be provided in case of failure. The

TABLE V—*Suitable Electromagnetic Pumps for Liquid Metal at Different Power Levels*

Output power level	Order of flow and pressure	Sodium	Bismuth
Low power	<25 g.p.m. <25 lb/in²	ACP (CT, MF)	ACP (CT, MF)
	25–100 g.p.m. <25 lb/in²	LIP ACP (CT, MF) ACP (ST, MF)	ACP (CT, MF) ACP (ST, MF)
Low power : high-pressure-low flow	<50 g.p.m. ~100 lb/in²	SIP	SDCP SACP (ST)
Medium power	<100 g.p.m. <50 lb/in²	LIP ACP (ST, MF) DCP	ACP (ST) DCP
	<1000 g.p.m. <100 lb/in²	LIP ACP (ST, LF) DCP	ACP (ST, LF) DCP
High power	>1000 g.p.m. ~100 lb/in²	LIP DCP	DCP Possibly ACP (ST, LF)

Initials	Pump
MF	Mains frequency
LF	Low frequency
ACP	A.C. (conduction) pump (CT, with combined transformer ; ST, with separate transformer)
SACP	Spiral a.c. conduction pump
DCP	D.C. (conduction) pump
SDCP	Spiral d.c. pump
SIP	Spiral induction pump
LIP	Linear induction pump, including
FLIP	Flat linear induction pump
ALIP	Annular linear induction pump, and
CALIP	Coaxial-flow annular linear induction pump

TABLE VI—FLUX AND CURRENT PENETRATION

Based on Maxwell's Equations

$$\phi H dl = \frac{4\pi}{10}\iint J dS$$

$$\phi E dl = -\frac{d}{dt}\iint \frac{B}{10^8} dS$$

In differential form

$$\nabla \times E = -10^{-8}\frac{\partial B}{\partial t} = i\left(\frac{\partial E_z}{\partial y} - \frac{\partial E_y}{\partial z}\right) + j\left(\frac{\partial E_x}{\partial z} - \frac{\partial E_z}{\partial x}\right) + k\left(\frac{\partial E_y}{\partial x} - \frac{\partial E_x}{\partial y}\right)$$

$$\nabla \times H = \frac{4\pi}{10} \cdot J$$

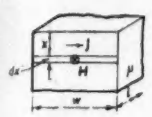
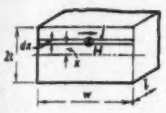
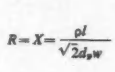
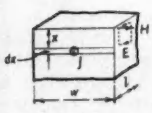
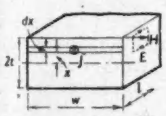
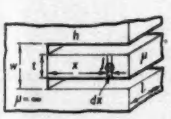
One dimensional case

$$\frac{\partial E_y}{\partial x} = -10^{-8}\frac{\partial B_z}{\partial t},\quad E_y = \rho J_y$$

$$-\frac{\partial H_z}{\partial x} = \frac{4\pi}{10} J_y,\quad B_z = \mu H_z$$

Hence, $$\frac{\partial^2 H}{\partial x^2} = k^2 \frac{\partial H}{\partial t}$$

and $$\frac{\partial^2 J}{\partial x^2} = k^2 \frac{\partial J}{\partial t}$$ where $$k^2 = \frac{4\pi\mu}{10^8\rho}$$

Configuration	Integral equations	Boundary conditions	H, ϕ or J, I expressions	L, R expressions: At low frequency	At high frequency	General
Flux Penetration —				Parallel equivalent circuit		
Flux in a semi-infinite plate 	$E = -\int_x^\infty \dot{B}10^{-8}dx$ $H = \frac{4\pi}{10}\int_0^x \frac{E}{\rho}dx$	$H=0,\ x=\infty$ or $H=H_s,\ x=0$ $\phi = w\int_0^\infty \mu H dx$	$\frac{H}{H_s} = e^{-\alpha x}(\cos \alpha x - j \sin \alpha x)$ $\phi = \mu H_s w/d(1+j)$	$\frac{R}{N^2} = \frac{\omega L}{N^2} = \omega\frac{4\pi\sqrt{2}d_s w}{10^9 l} = \frac{\rho w}{l d_s/\sqrt{2}}$		
Flux in a lamination ($w \gg t$) 	$E = -\int_0^x \dot{B}10^{-8}dx$ $H = \frac{4\pi}{10}\int_x^t \frac{E}{\rho}dx$	$\frac{\partial H}{\partial x} = 0,\ x=0$ $H=H_s,\ x=t$ or $\phi = 2w\int_0^t \mu H dx$	$\frac{H}{H_s} = \frac{C'c' + jS's'}{Cc + jSs}$ $\frac{\phi}{B_s} = \frac{2wt}{(1+j)\alpha t} \cdot \frac{S_2 + js_2}{C_2 + c_2}$	$\frac{R_{LF}}{N^2} = \frac{6w\rho}{lt}$ $\frac{L_{LF}}{N^2} = \frac{4\pi\mu 2tw}{10^9 l}$	$\frac{R_{HF}}{N^2} = \frac{2w\rho}{l d_s/\sqrt{2}}$ $\frac{L_{HF}}{N^2} = \frac{4\pi\mu 2\sqrt{2}d_s w}{10^9 l}$	$\frac{R}{R_{LF}} = \frac{1}{f_r(\zeta)}$ $\frac{L}{L_{LF}} = f_m(\zeta)$ $\zeta = \alpha t = t/\sqrt{2}.d_s$
Flux in a slab between poles ($c \gg b$)	$E = \int_x^t \dot{B}10^{-8}dx$ $\frac{B_a}{\mu_a} = \frac{4\pi}{10}\int_x^t J a dx$ $\frac{1}{\mu_a} = \frac{1}{\mu} + \frac{d-a}{a}$	$\frac{\partial H}{\partial x} = 0,\ x=0$ $H=H_s,\ x=t$ or $\phi = 2w\mu\int_0^t H dx$	$\frac{B}{B_s} = \frac{C'c' + jS's'}{Cc + jSs}$ $\frac{\phi}{B_s} = \frac{bc}{(1+j)\alpha t} \cdot \frac{S_2 + js_2}{C_2 + c_2}$	$\frac{R_{LF}}{N^2} = \frac{12\rho c}{ab}$ $\frac{L_{LF}}{N^2} = \frac{4\pi\mu_a bc}{10^9 a}$	$\frac{R_{HF}}{N^2} = \frac{2\rho c}{a d_s/\sqrt{2}}$ $\frac{L}{N^2} = \frac{4\pi\mu_a 2\sqrt{2}d_s c}{10^9 a}$	$\frac{R}{R_{LF}} = \frac{1}{f_r(\zeta)}$ $\frac{L}{L_{LF}} = f_m(\zeta)$ $\zeta = \alpha t = b/2\sqrt{2}d_s$
Current Penetration —				Series equivalent circuit 		
Current flowing in semi-infinite slab 	$H = \frac{4\pi}{10}\int_x^\infty J dx$ $\frac{V}{l} = \rho J + \int_0^x \frac{\dot{B}}{10^8}dx + \int_{-\infty}^x \frac{\dot{B}}{10^8}dx$ Last term neglected	$\left.\begin{matrix}H=0,\\ J=0,\end{matrix}\right\} x=\infty$ $J=J_s,\ x=0$ or $I = w\int_0^\infty J dx$	$\frac{J}{J_s} = e^{-\alpha x}(\cos \alpha x - j \sin \alpha x)$ $I = \frac{J_s w}{\alpha(1+j)}$	$R = X = \frac{\rho l}{\sqrt{2}d_s w}$		
Current in a lamination ($w \gg t$) 	$H = \frac{4\pi}{10}\int_0^x J dx$ $\frac{V}{l} = \rho J + \int_x^t \frac{\dot{B}}{10^8}dx + \int_t^\infty \frac{\dot{B}}{10^8}dx$ Last term neglected	$\frac{\partial J}{\partial x} = 0,\ x=0$ $J=J_s,\ x=t$ or $I = 2w\int_0^t J dx$	$\frac{J}{J_s} = \frac{C'c' + jS's'}{Cc + jSs}$ $\frac{I}{J_s} = \frac{2w}{(1+j)\alpha} \cdot \frac{S_2 + js_2}{C_2 + c_2}$	$R_{LF} = \frac{\rho l}{2wt}$ $L_{LF} = \frac{4\pi\mu t l}{6 \cdot 10^9 w}$	$R_{HF} = \frac{\rho l}{2\sqrt{2}d_s w}$ $L_{HF} = \frac{\rho l}{2\sqrt{2}d_s w}$	$\frac{R}{R_{LF}} = \frac{1}{f_m(\zeta)}$ $\frac{L}{L_{LF}} = f_r(\zeta)$ $\zeta = \alpha t = t/\sqrt{2}d_s$
Current in an armature bar ($h \gg w$) 	$\frac{B}{\mu_a} = \frac{4\pi}{10}\int_0^x J dx$ $\frac{V}{l} = \rho J + \int_x^h \frac{\dot{B}}{10^8}dx + \int_h^\infty \frac{\dot{B}}{10^8}dx$ $\frac{1}{\mu_a} = \frac{1}{\mu} + \frac{w-t}{t}$	$\left.\begin{matrix}H=0\\ \frac{\partial J}{\partial x}=0\end{matrix}\right\} x=0$ $J=J_s,\ x=h$ $I = t\int_0^h J dx$	$\frac{J}{J_s} = \frac{C'c' + jS's'}{Cc + jSs}$ $\frac{I}{J_s} = \frac{t}{(1+j)\alpha} \cdot \frac{S_2 + js_2}{C_2 + c_2}$	$R_{LF} = \frac{\rho l}{th}$ $L_{LF} = \frac{4\pi\mu_a h l}{3 \cdot 10^9 t}$	$R_{HF} = \frac{\rho l}{\sqrt{2}d_s t}$ $L_{HF} = \frac{\rho l}{\sqrt{2}d_s w}$	$\frac{R}{R_{LF}} = \frac{1}{f_m(\zeta)}$ $\frac{L}{L_{LF}} = f_r(\zeta)$ $\zeta = \alpha h = h/\sqrt{2}d_s$

Symbols: C.G.S. units:

d_s = depth of penetration. $= \left(\frac{12 \cdot 66 \cdot 10^8 \rho}{\mu_a f}\right)^{\frac{1}{2}}$

$\alpha = 1/\sqrt{2}.d_s = k^2\sqrt{\omega/2}$.

μ = permeability.

μ_a = effective permeability.

ρ = resistivity.

ω = angular frequency $= 2\pi f$.

$C' = \cosh dx$. $c' = \cos dx$. $S' = \sinh dx$. $s' = \sin dx$.

$C = \cosh \zeta$. $c = \cos \zeta$, &c. $C_2 = \cosh 2\zeta$. $c_2 = \cos 2\zeta$, &c.

d.c. pump with homopolar generator suffers from the disadvantage that the generator must be close to the pump, and in the event of generator failure switching the heavy busbars to an alternative generator is difficult and expensive. The maintenance of a homopolar generator located close to a pump containing radioactive liquid at high temperature is also a problem. At the present time there is little doubt that a low-frequency a.c. conduction pump and auxiliaries is the most reliable arrangement and it is also cheaper than a d.c. pump together with its supplies and controls.

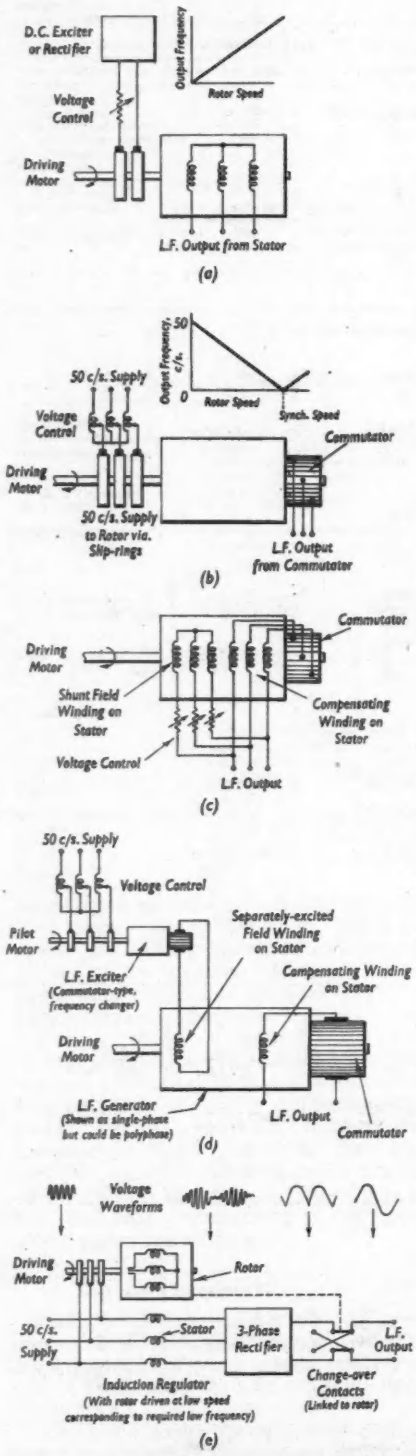


Fig. 12—Low-frequency generating equipment: (a) l.f. alternator; (b) commutator type frequency changer; (c) self-excited, commutator type, low-frequency generator; (d) separately excited, commutator type, low-frequency generator; (e) l.f. generation scheme without commutator machines

However, if simple and reliable homopolar generators with liquid metal brushes can be developed the situation might be reversed.

The factors which control the upper limit of size of the low-frequency a.c. conduction pump have not been definitely established. Low-frequency generators can be built for ratings of 1000kVA without great difficulty, and higher ratings than this should be possible. Experiments have been conducted to examine the feasibility of constructing large d.c. pumps and, based on this experience, it would appear that the construction of low-frequency a.c. pumps of 1000kVA would not present insuperable difficulties. Perhaps a more fundamental limitation to size is the cyclic variation of pump pressure, and consequently of liquid velocity associated with low-frequency operation. For example, in the 250 g.p.m., 75 lb per square inch, 5 c/s design of Table III, the velocity variation about the mean would be ±4 per cent, assuming a 3in diameter pipe system and a mass of liquid of 500 lb. Due to elasticity in the pipework, not all the 500 lb would contribute inertia; if there is an extreme degree of elasticity in the pipe system immediately adjoining the pump, so that only the mass of liquid within it effectively limits the velocity fluctuations, the figure would rise to ±25 per cent. In practice the pipework has a finite elasticity which will restrict the velocity variation to a more acceptable level, but care would have to be exercised to avoid mechanical resonance.

Provided resonance effects are kept under control, it is to be hoped that low-frequency a.c. conduction pumps could remain competitive with d.c. pumps up to the largest sizes of pump so far envisaged, at least with high-density liquids like bismuth, where the mass of liquid in the system is likely to be large enough to restrict velocity variations to an acceptable level, so that hydraulic losses are not appreciably increased or heat transfer properties noticeably affected. As a further example an a.c. conduction pump of 2000 g.p.m., 75 lb per square inch for bismuth would require a single-phase supply of 1 c/s to 1·5 c/s frequency (and 120,000A at 4V). Assuming a 10in diameter pipe system and a mass of liquid of 7½ tons, the velocity variation could be kept to 8 per cent ideally.

Acknowledgments

The author is indebted to Mr. Raby, of plant engineers' department, the British Thomson-Houston Company, Ltd., Rugby, for supplying the information on low-frequency generators given in Appendix II, and also to his colleagues in the B.T.H. research laboratory, for their helpful criticism and assistance in constructing and testing pumps of the type described. The Atomic Energy Research Establishment, Harwell, sponsored much of the original work on electromagnetic pump development, and the author gratefully acknowledges their encouragement.

Appendix I.—Flux and Current Penetration Effects

Skin or penetration effect largely sets a limit to the size of the a.c. conduction pump and affects its performance.

To assist calculations, Table VI is prepared which summarises useful expressions: they are arranged as far as possible to make apparent the physical significance of the terms, so that the expressions can be readily modified to suit the more complicated cases occurring in practice. In the case of flux penetration, leakage flux has been ignored, which will give rise to an additional leakage inductance term. Similarly, in the case of current penetration, the contribution to the inductance term due to flux external to the conductor has also been ignored. These terms are usually large and cannot be neglected, but they can be estimated only if the core and winding geometry is specified more precisely.

Table VII—*Low-Frequency Generators*

Type of generator	Alternator	Commutator type* frequency changer	Commutator type* low-frequency generator (self-excited)	Commutator type low-frequency generator (separately excited)
Equipment	Alternator driving motor; d.c. supply for alternator field (exciter or rectifier); field rheostat or automatic regulator	Frequency changer; driving motor; variable-ratio transformer	L.F. generator; driving motor; shunt field rheostat	L.F. generator; driving motor; l.f. exciter (commutator type frequency changer)
Optimum output conditions	Above 15 c/s, any required kVA, any required voltage, single or polyphase	0–50 c/s, 0–25kVA single-phase or 50kVA polyphase, about 50V, preferable polyphase	0–15 c/s, 50–500kVA, 50–100V, polyphase preferably	0–15 c/s, 50–500kVA, 50–100V, single or polyphase
Method of voltage control	Control of alternator field current	Control of 50 c/s input voltage to frequency changer	Shunt field rheostat (limited voltage range)	Control of 50 c/s input voltage to l.f. exciter
Method of frequency control	Variation of alternator speed	Variation of speed of frequency changer	Tappings on generator shunt field windings	Variation of speed of l.f. exciter
Function of driving motor	Supplies output power ...	Supplies running losses only	Supplies output power ...	Supplies output power
Schematic diagram ...	Fig. 12(*a*)	Fig. 12(*b*)	Fig. 12(*c*)	Fig. 12(*d*)

* For further details, refer to Adkins and Gibbs, *Polyphase Commutator Machines*, Cambridge University Press, 1951

Appendix II.—Low-Frequency Generators for A.C. Pumps

Low-frequency generators are required for a.c. pumps for a frequency output from about 15 c/s, when about 20kVA would be the maximum rating requirements, down to about 1 c/s, when up to 1000kVA may be required. To cover this range, several types of low-frequency generator may be necessary and a short description of some of them and their characteristics are summarised in Table VII and Fig. 12. It is difficult to indicate costs of the different machines, but as a guide the l.f. commutator type generators are very approximately three times the cost of a d.c. machine of the same kilovolt-ampere rating.

In addition to the rotary machines described in Table VII, there is another low-frequency supply equipment worthy of mention, suggested by L. C. Ludbrook.* This is represented in Fig. 12(*e*). It consists of a single or three-phase induction regulator whose rotor is driven at a low speed so that the output is modulated at the required low-frequency. The output is rectified and then converted to low-frequency a.c. by change-over contacts, the design of which could follow contact-rectifier practice; alternatively, a commutator type switch could be employed, possibly using liquid metal brushes. This l.f. supply equipment has distinct possibilities, for it should be smaller, more reliable and require less maintenance than rotary machines with commutators.

* Electronics engineers' department, The British Thomson-Houston Company, Ltd., Rugby.

North of Scotland Hydro-Electric Schemes

No. VIII: THE GARRY AND MORISTON SCHEMES—PART IV*

(*Continued from page 546, October 19th*)

The adjoining catchments of the Garry and Moriston rivers in Inverness-shire have for many years been recognised as favourable sources for the development of hydro-electric power. The North of Scotland Hydro-Electric Board's developments here will yield about 383 million kWh annually, from an installed capacity of 106MW. Here the 22MW horizontal-shaft Francis turbine set at Quoich, and the 20MW high-head Kaplan set at Invergarry are described: other matters in the electrical engineering of the Garry scheme are also discussed.

EACH of the two power stations of the Garry scheme contain only one principal generating set. We have discussed in a previous article (No. VII in this series) how this economical arrangement has evolved in the more recent Scottish schemes, due to greater flexibility in the operation of modern turbines, the further operational flexibility given by the grid system, and due to improvements in control. Apart from exemplifying this trend, the two sets concerned each present some interesting points in their design and construction.

In the upper station, the set has a horizontal shaft, and is driven by a Francis turbine. No other horizontal shaft Francis turbine set (apart from small compensation water machines) has up to now been installed on the Board's own schemes. The set has three main bearings with a thrust bearing between the turbine and the alternator, and a flywheel and the exciter mounted on the alternator side. It may be of interest to recall here one of the few instances of large Francis turbine sets with the horizontal shaft layout built recently. We refer to the Peage-de-Vizille power station in France (THE ENGINEER, December 7, 1951), where two such sets, each of 29MW, are installed. In this case, however, the turbines have a double runner; the runner consists in effect of two "normal" sets of runner blades with a solid disc between them, and central draught tubes. These machines operate at 500 r.p.m.

The set at Quoich power station is illustrated in Fig. 9. The turbine house measures 47·5ft by 74·5ft, and the horizontal Francis turbine drives a 23·1MVA, 0·95 p.f. alternator. The turbine is capable of operating when the net head is 231ft to 304ft at a normal speed of 300 r.p.m. The maximum efficiency, however, is obtained at an output of 25,000 b.h.p. at a net head of 274ft.

At the turbine inlet there is a butterfly valve 9ft in diameter. The periphery of the blade of this valve has a rubber hose ring to which pressure water from the upstream side of the valve is admitted to ensure a tight seal. The valve is operated hydraulically by water from the pipeline and incorporates a by-pass valve which is used to fill the spiral casing before the main valve is open. It will close under unbalanced conditions, which may occur under full flow. Opening and closing of the main and by-pass valves in the correct sequence is effected by a solenoid-operated pilot valve. In order to reduce the station width to a minimum the main valve was designed with a vertical shaft, and the hydraulic operating cylinders for the valve blade were mounted on the top of the valve. Thus the inlet valve was positioned nearer to the spiral casing than would have been the case with the conventional horizontal-shaft blade and vertical operating mechanism.

The turbine runner, which is of Nikalium bronze cast in one piece having a nominal diameter of 1850mm and weighing 5·3 tons, is mounted overhung on the alternator shaft.

The spiral casing is of fabricated steel in two sections with a horizontal bolted joint and an air exhaust valve on the highest point.

A pressure relief valve is provided on the spiral casing. The valve is automatic in action and opens immediately the guide vane servo-motor closes. The rate of valve closure is controlled by an oil dashpot and is timed so that excessive rises in pressure in the pipeline do not occur when the load on the turbine is suddenly removed. The valve is held closed by pipeline water pressure in its cylinder and is opened by the combined action of its weight and the internal pressure when the water in the cylinder is released by a pilot valve.

The governing system comprises an actuator, a servo-motor and an electrically driven governor oil pumping set for normal operation, with a Pelton-turbine-driven oil pump as standby. The pendulum of the actuator is driven by a synchronous motor which is supplied from an auxiliary permanent magnet generator mounted on an extension of the alternator shaft which contains the exciter group, thus ensuring that it rotates in step with the alternator shaft, but at a higher speed.

The movements of the actuator caused by changes in speed of the turbine are transmitted to a pilot valve which controls a regulating valve, and this in turn determines the setting of a small servo-motor. The movements of this servo-motor, which is fitted inside the actuator, are transmitted to a further regulating valve which controls the admission of oil to the piston of the turbine servo-motor. This piston, which is coupled to the guide vane regulating ring through a connecting-rod, then moves correspondingly until the return gear on the servo-motor replaces the regulating valve. All controls for manual starting and for regulating the speed of the turbine are mounted on the actuator. Local manual and automatic supervisory control changeover switches are provided on the turbine gauge panel.

A pump is installed to dewater the tunnel, draft tube and spiral casing in approximately twelve hours. This pump also acts as a standby to the smaller pump provided for normal station drainage, and both pumps are controlled by an electrode system which also gives high water sump level alarm and indication.

The turbine has been arranged so that operation of the alternator as a synchronous condenser can be adopted in the future if required.

The alternator has a maximum continuous rating of 23·1MVA at 0·95 p.f. at a normal speed of 300 r.p.m., but has been designed to withstand a maximum runaway speed of 580 r.p.m. The rotor hub is built of thick plates bolted together to form a solid hub, which is shrunk on the alternator shaft. The poles are of laminated steel construction with dovetails which are fitted, with taper side keys, into slots machined on the outer periphery of the rotor hub. Pipeline characteristics demanded that a flywheel, of built-up thick plates, was necessary in addition to the kinetic energy provided in the alternator rotor design, to provide adequate governing stability. The alternator is an open-circuit-ventilated machine, the air being drawn into it by fans mounted on the rotor hub; air cooling is assisted by the fanning action of the salient poles themselves and the air is discharged to the station from the top of the stator. There are exhaust louvres below the station roof, and fresh air is drawn in through louvres and filters mounted in the upstream wall of the station.

The main thrust and journal bearing has a white-metal-lined bush and double thrust pads, whereas the other two main journal bearings are of the Michel pivoted pad type. All three bearings are lubricated from a separate auxiliary unit comprising an oil sump and main a.c.-motor-driven pump; a d.c.-motor-driven standby pump is available in the event of failure of the external a.c. supplies. The exciter pedestal bearing is a conventional oil-ring-lubricated bearing.

The stator is split on the horizontal centre line. The 11kV class B insulated winding is of the two-layer type held by wedges in open slots.

The heaviest lift in the station is the complete rotor. A 110-ton electric overhead travelling crane with a gantry rail spacing of 45ft is installed, with an auxiliary hoist of 20 tons on the main crab to give better handling of the smaller items of plant. In addition, there is a hand chain block for the removal of the draft tube cone and the turbine runner.

GENERATING SET AT INVERGARRY

At Invergarry power station a vertical-shaft feathering propeller turbine driving a 23·5MVA, 0·85 p.f. alternator is installed, as illustrated in Fig. 10, in a power-house, measuring 81ft by 50ft. The turbine is capable of operating over a net head range of 129ft to 162·5ft at a normal speed of 250 r.p.m. The maximum efficiency is obtained at an output of 21,000 b.h.p. at a net head of 146·5ft.

The head is high for a Kaplan machine, and illustrates a trend which has been very marked in recent Kaplan turbine installations in several countries, and has resulted in an increase in the upper limit of the range of heads for such machines. A number of examples of recently developed high-head Kaplan turbines were discussed in the papers of the fifth World Power Conference held in Vienna last June. They included several machines operating with heads of about the same value as the Invergarry turbine, and, in one case, a project for a Kaplan turbine with a head of nearly 240ft (paper H24). This machine will have the following characteristics:—Output, 85MW; range of heads 44m to 71m; flow, 150 cumecs; speed, 187 r.p.m. Economies are gained by introducing Kaplan machines for these higher heads, but in the case just mentioned competition from the Francis machine was severe, and the Kaplan gained its advantage because of its flat efficiency curve over a considerable range of heads. The position at Invergarry was described at the conference by Mr. M. Braikevitch, and we reproduce the section

* No. I: "An Introductory Survey," appeared July 14, 1950; No. II: "The Loch Sloy Project," July 21-August 4, 1950; No. III: "The Fannich Project," June 8-15, 1951; No. IV: "The Mullardoch-Fasnakyle-Affric Project," April 11-25, 1952; No. V: "Some Schemes for Local Supply," October 16-23, 1953; No. VI: "The Tummel Garry Scheme," September 2-23, 1955; No. VII: "The Shira Scheme," April 20-27, 1956.

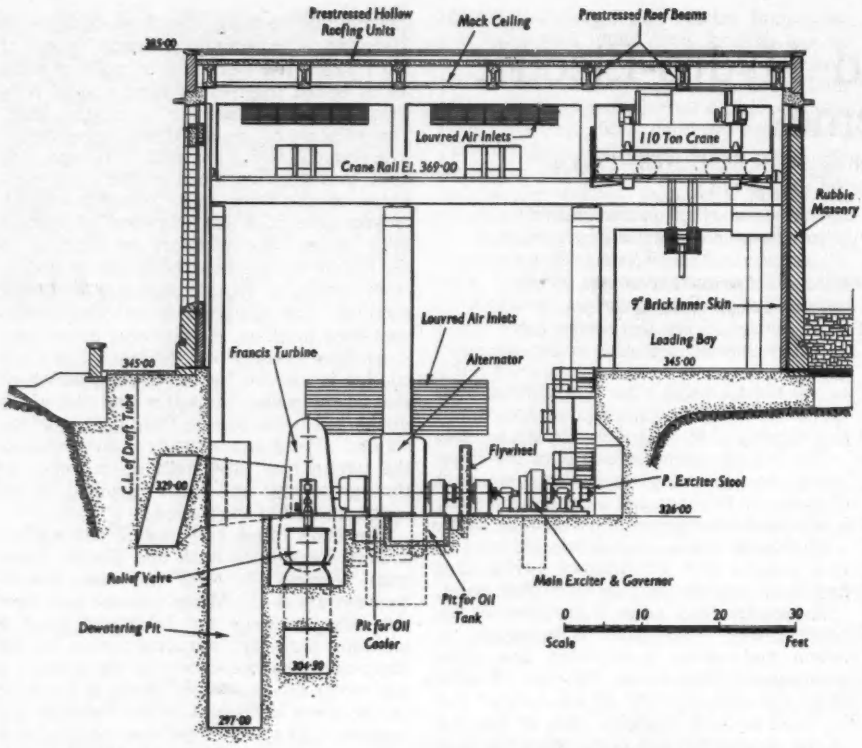


Fig. 9—Section through Quoich Power Station showing layout of 22MW horizontal-shaft Francis turbo-alternator set

from his paper (H/37, "Some British Developments in Large Plant for Hydro-Electric Power Generation") discussing the Invergarry turbine in the next two paragraphs.

"For this scheme two reaction turbines were initially considered, since for considerable periods less than half the full flow was available. However, with the availability of Kaplan turbines for heads of 181ft, the two units were merged into one of 28,000 b.h.p., running at 250 r.p.m., with considerable economies in the electrical equipment and power station. The runner is 9ft 5in diameter, has eight stainless steel vanes, and a servo-motor in the hub so as to avoid the transmission of large forces. The distributing valve is inside the hub servo-motor to obtain the greatest precision. The runner envelope of clad stainless steel is spherical above as well as below the vane centre line. Thus a fine clearance is maintained between the envelope and the whole length of the vane at all openings, and gap cavitation is avoided.

"Since 1926, when we supplied our first electrically welded spiral casings, the use of electric welding in water turbine building has been continually extended. For Invergarry virtually only the runner, the bearing assembly and, of course, the shaft are not fabricated. An unusual feature is the relief valve, made necessary by the length of the pipeline, which is 1025ft or 5·7 times the head. In spite of its 6ft 6in bore the valve occupies relatively little space. This is because the design avoids a bend. The annular orifice at the mouth is controlled by a sliding cylinder and the discharge, in the shape of a hollow cone, is led straight into the tail-race. The absence of bends with the valve as a direct extension of the pipeline reduces pressure rise and eliminates vibration. The valve piston is operated by a differential oil pressure servo-motor acting through a rocking lever. This servo-motor holds the valve closed by pressure oil from the oil pressure system of the governor. On the other hand, should the turbine close rapidly, the governor servo-motor forces oil under pressure into the opening side of the relief valve servo-motor, thereby overcoming the closing side and opening the valve. This oil is allowed to escape through a diaphragm so that the constant pressure in the closing side of the valve servo can reclose the relief valve. The governor servo-motor, in fact, opens the valve, thereby eliminating any danger of the valve not opening—an important feature with a long pipeline."

The turbine is fitted with a 12ft diameter butterfly valve, which is situated under the erection bay on an extension of the spiral casing inlet pipe. The periphery of the valve blade is sealed by a rubber hose ring as in the case of the Quoich inlet valve, and it is designed to close under unbalanced conditions which may occur under full flow. The valve blade is mounted on a horizontal shaft with a single external vertical hydraulic operating cylinder and an electrically operated by-pass valve for filling the spiral casing.

Each of the eight stainless steel blades of the turbine runner has a transition column, trunnion and operating lever. The operating levers are connected to the moving cylinder of the hub servo-motor by short links. The piston, which is bolted to the hub casing, carries the distributing valve which is rod-operated from the governor for setting the blade angle relative to the guide vane opening. An oil pressure head is mounted on the top of the generator incorporating ports for the oil supply to the runner servo-motor and hub, and it is complete with special piping passing down the alternator and turbine shafts connecting to the distributing valve and return motion cylinder.

The governing system comprises an actuator, twin servo-motors and an electrically driven governor oil pumping set with an automatic reaction-turbine-driven oil pump for standby duties. The pendulum of the actuator is driven by a synchronous motor, which is supplied by a permanent magnet generator mounted on the exciter shaft below the main exciter. The actuator is mounted in a cabinet forming part of the combined gauge panel, and local manual/automatic supervisory controls and change-over switches are provided.

The low setting of the inlet pipe in relation to the tail-race level has, as in the case of Quoich, necessitated installation of a pump to dewater the pipeline, spiral casing and draught tube, and also to act as a standby for the normal station drainage pump. The turbine has a grease lubricated guide bearing, which is positioned at the lower end of the turbine shaft in the turbine top cover. The turbine has been arranged so that the alternator may be operated as a synchronous condenser.

The alternator is a two-bearing machine with an overhead thrust bearing, and has a maximum continuous rating of 23·5MVA at 0·85 p.f. at a normal speed of 250 r.p.m. It has been designed to withstand a maximum runaway speed of 625 r.p.m. The rotor is similar in construction to the Quoich machine. The alternator cooling system is single-duct ventilated with louvres and air filters mounted in the intake passage; the hot air discharges into the station. Low-temperature heaters maintain the alternator windings at a temperature in excess of the ambient when the machine is not operating.

The whole weight of the revolving parts is carried by a pivoted pad thrust bearing mounted on the upper bracket. The rotating load is transmitted through a thrust bell which has a highly polished face and the bronze white-metal-lined pads are pivoted to enable them to tilt freely in any direction. They are independently adjustable to ensure that each can carry its share of the load. A guide bearing is housed in the same oil reservoir and is also a pivoted pad bearing with individual adjustment for each pad and facilities for locking. A second guide bearing is mounted in a lower bracket between the rotor hub and the coupling. This guide bearing is mounted in a light hub in halves, the length of the shaft being such as to permit easy assembly from below. The lubricating oil is circulated through the bearings continuously by duplicate a.c.-motor-driven pumps. The oil level in the reservoir is maintained by a weir so that in the event of temporary cessation of oil supply the set can continue to operate for fifteen minutes without injurious heating.

The station crane has a main hoist capacity of 130 tons and a span of 49ft 6in, with an auxiliary hoist of 20 tons. The excavation for the station cut into the side of a steeply rising slope, and advantage was taken of this to extend the length of the station and roof above crane rail level at the loading bay end of the station, permitting reduction in size of the loading bay.

Electrical Systems

The machines at Quoich and Invergarry are protected on the 11kV system by 11kV metal-clad oil circuit breakers, each having a rupturing capacity of 250MVA, the current capacity being 1600A. Each of these switches has cable boxes both on the incoming and busbar sides and the protection includes the mounting of the protective gear current transformers so that the protected systems overlap the circuit breaker.

Each station has a 25MVA, 132/11kV, oil-natural-cooled transformer with "on-load" tap change equipment. To assist the regulation of the system, tappings of 0 to plus 15 per cent were selected, which can be adjusted by

links to a somewhat lower range of minus 5 per cent to plus 10 per cent. The earthing and auxiliary transformer is connected direct to the lower voltage winding of the transformer and serves the dual purpose of providing an earthing point for the 11kV system and providing a non-unit auxiliary supply for the power station.

Automatic control equipment enables the sets to be started with a push button. The running up of the machine and the ultimate closing down is fully automatic. After shut down the equipment resets ready for the next starting sequence. The main switchgear has the usual instrumentation and, in addition, automatic selection of voltages for synchronising.

Two zones of overall differential protection by the Reyrolle duo-bias system are provided at each station, one to protect the generator circuit up to the 11kV circuit breaker and the second one from the circuit breaker to the higher voltage side of the main transformer. Thus complete protection is provided for the two zones.

The 132kV circuit breakers have been dispensed with, but in their place there are transformer feeders, which connect with the main 132kV transmission system linking Fort Augustus with Fort William. Faults which might occur on the transformer are dealt with by the use of a 132kV fault throwing switch, which is designed to place an artificial fault on one phase of the 132kV system and thus trip automatically the corresponding 132kV circuit breaker at the main switching station at Fort Augustus.

The 132kV isolators at the generating stations are motor operated so that they may be controlled from the main control board within the power station. Each isolator is equipped with hand-operated earthing blades for earthing the o.h. lines during maintenance. Interlocks ensure correct operation. Each alternator has an enclosure on the neutral side for containing the current transformers and the neutral link which is normally left open, the earthing of the 11kV system being completed by the earthing transformer and earthing resistor referred to above.

Station Auxiliaries

Each station has been designed with the minimum of auxiliaries, with the aim of simplifying operation and maintenance, and improving overall reliability. In both stations there is a unit auxiliary contactor board, which depends upon its normal supply from a unit auxiliary transformer connected to the main terminals of the alternators. A manual change-over switch on this board enables an emergency supply to be obtained from the station common services board. This latter board is conventional, but is provided with an automatic change-over gravity contactor for maintaining supplies to the station, either from a non-unit transformer connected to the nearby 33kV system or from the auxiliary winding of the earthing transformers, which have been described above.

A further feature of these stations is the avoidance, as far as possible, of d.c. operated auxiliaries, to simplify and reduce the burden on the station battery and charging plant. An exception to this rule has occurred at Quoich, where a 110V d.c. operated alternator bearing lubricating oil pump has had to be installed. Oil has to be pumped through this bearing until the machine is brought to rest.

Group Control Centre

The power stations of the Garry group come under the jurisdiction of a group control centre which has been established at the 132kV switching station at Fort Augustus. This station provides a main switching point for a number of 132kV lines which radiate south to Fort William and north to Fasnakyle and Beauly and east to Errochty and Aberdeen via the Corrieyairack Pass. Further lines radiate to the Garry and Moriston valleys to the power stations.

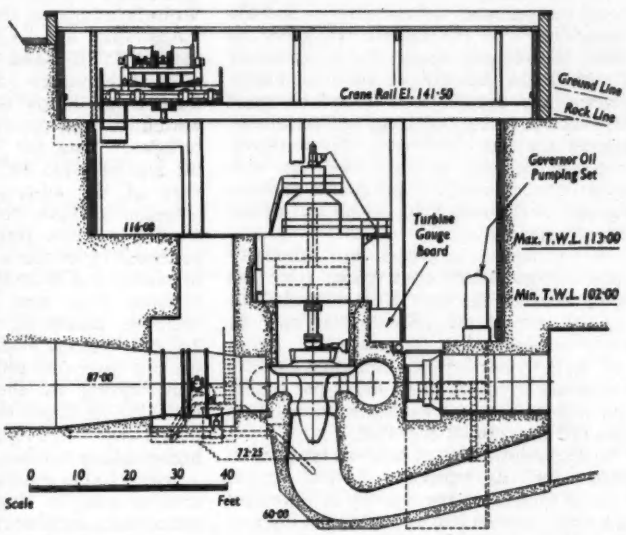


Fig. 10—Invergarry power station. The 20MW generating set is powered by an eight-bladed Kaplan turbine operating under a head of about 180ft

At the present time the control centre has a miniature direct-wire control equipment for the 132kV switchgear and space has been left for the possible future supervisory control of the power stations in the Garry and the Moriston groups. The general alarms are brought back from the power stations in addition to indicating the megawatts and megavars of the individual machines. These indications are displayed continuously at the group control centre.

Communications

Communication between the group control centre and the power stations of the Garry and the Moriston groups is by the injection of carrier current into the 132kV lines which radiate from the 132kV switching station at Fort Augustus up the two valleys. Over this carrier current system are superimposed voice frequency telegraph circuits which enable meter readings, alarms and communications to be established. Extensions from this communication system are also made by pilot wires to the headworks and small compensation stations.

Compensation Water Stations

The fish lock at Invergarry passes, on average, a flow of 16 cusecs. The total compensation water requirements are 28 cusecs in the winter period and 120 cusecs in the summer. To give efficient operation utilising the balance of compensation water which has to be supplied, two induction generator sets have been installed, one of 30kW and the other of 285kW capacity. The smaller machine is estimated to pass an average of 12 cusecs over the winter period of 212 days and the larger machine to pass an average of 99 cusecs over the summer period of 153 days. The 285kW generator runs at 760 r.p.m. and is driven through a pair of single helical gears by a vertical Francis turbine running at 230 r.p.m. The smaller set also uses a vertical Francis turbine, with direct drive, running at 762 r.p.m.

At Quoich the Board has installed in the dam a horizontal Francis turbine developing 310/518 b.h.p. at 760 r.p.m., driving an induction generator rated at 350kW. This unit is capable of discharging 45 cusecs over a head range of 75ft to 123ft. A 12in hydraulically-operated solenoid-actuated by-pass valve is also provided.

The compensation sets at the Invergarry and Quoich dams are connected to a 33kV overhead line system which has been built through the valley and connects back to the Board's main 33kV system at the Beauly switching centre. A medium-voltage air circuit breaker controls each generator, the output from which is then stepped up by a transformer direct to the 33kV system. Auxiliary services for the compensation water station and headworks are derived from the medium-voltage switchboard which contains the air circuit breaker.

The compensation water power stations and headworks will be interconnected with their respective generating stations by a pilot cable consisting of polyvinyl insulated cores protected by polyvinyl chloride sheathing and steel wire armouring. The route to be taken by this cable in parts is so far from habitation that the cable will be laid overground. In other parts, especially where the Forestry Commission has tree plantations, the cable will be ploughed into the top soil.

The works described in this section of our article are under the responsibility of the mechanical and electrical consultants, Messrs. Kennedy and Donkin. The main contracting firms associated with the electrical and mechanical aspects of the Garry scheme are listed below :

Quoich and Invergarry power stations : water turbine, alternator and ancillary equipment, Boving and Co., Ltd. (Quoich only), English Electric Company, Ltd.; 11kV switchgear, A. Reyrolle and Co., Ltd.; power and auxiliary cables, Malcolm and Allan, Ltd.; main power transformers, Bruce Peebles and Co., Ltd.; lighting and heating, Aberdeen Electrical Eng. Company, Ltd. (Quoich), Malcolm and Allan, Ltd. (Invergarry) ; 132kV motor-operated isolators and fault-throwing switches, Switchgear and Equipment, Ltd.; medium-voltage auxiliary switchgear, E. Holme and Co. (1931), Ltd.; power station crane, Sir W. Arrol and Co., Ltd.; station batteries and chargers, Chloride Batteries, Ltd. (Quoich), Nife Batteries (Invergarry) ; 132kV lightning arresters, ASEA Electric, Ltd.; pilot cables for the headworks, Pirelli General Cable Works, Ltd.

Compensation water power stations : 350kW induction set for Quoich, Gilbert Gilkes and Gordon, Ltd.; 285kW and 30kW induction sets for Invergarry, Armfield Hydraulic Engineering Company, Ltd.; medium-voltage switchgear, English Electric Company ; cables, lighting and heating, Malcolm and Allan, Ltd.; 3-ton travelling crane, Invergarry, Vaughan Crane Company ; lifting appliances, Quoich, W. Thomson and Co., Ltd.

Fort Augustus : main 132kV switchgear, A. Reyrolle and Co., Ltd.; 132kV lines, J. L. Eve Construction Company, Ltd.; carrier current communication system and miniature direct-wire control equipment, General Electric Company, Ltd.; telemetering, Standard Telephones and Cables, Ltd.

(To be continued)

Motive Power on Sea and Land

By T. A. CROWE, M.Sc.

No. I.

Abstracts are printed here of the presidential address delivered by Mr. T. A. Crowe before the Institution of Mechanical Engineers last Friday, October 19th. Mr. Crowe drew upon his own experiences in marine and railway engineering. We print here those parts of the address which related to the Royal Navy and the development of diesel locomotives.

I WAS fortunate to commence my engineering career when I did, because the early days of the period under review saw a rapid advance in naval machinery. The early days of the 1914–18 war saw the final change over from coal to oil, and from the direct-drive turbine to the geared turbine. As an apprentice I worked on the machinery of the battleship "Warspite" which did such splendid service in the 1939–45 war when nearly thirty years old. She belonged to the first class of battleships to burn oil fuel only, and her machinery was designed for 80,000 s.h.p., which was the highest power put into a battleship up to that time, and indeed for many years afterwards. I also worked on the machinery of the battleship "Royal Oak" of 40,000 s.h.p., which came to such a tragic end in Scapa Flow in the early days of the 1939–45 war. This vessel was originally designed to burn coal as well as oil, but was changed during construction to burn oil fuel only. It was also one of the last battleships to be built with direct-drive turbines. A third historic vessel upon which I was employed as an apprentice was the light cruiser "Champion" of 30,000 s.h.p., because she was the first cruiser to be fitted with geared turbines and the Michell thrust block.

The next major step forward in the design of naval machinery was the introduction of superheated steam, of which my first experience was in the cruiser "Kent," completed in 1928, and in the destroyers "Active" and "Antelope," completed in 1930. The "Kent" was also one of the first naval vessels to be fitted with the closed-feed system and turbine-driven auxiliary machinery. The boiler pressure remained practically constant over this period, being 235 lb per square inch in the "Warspite" and 250 lb per square inch in the "Kent."

From the time of the "Kent" class cruisers until the end of the 1939–45 war the design of naval machinery continued to make steady progress, even if no spectacular change took place.

An indication of the advance made in the design of naval machinery between the beginning of the 1914–18 war and the beginning of the 1939–45 war is provided by the re-engining of the "Warspite," which was built in 1915 and re-engined in 1940.

TABLE I—"*Warspite*" *Propelling Machinery of 80,000 s.h.p.*

	1915		1940
Weight of main engines and boilers, tons	3080	...	1570
Steam consumption at full power per shaft horsepower per hour	12·8	...	9·4
Steam consumption at one-fifth power per shaft horsepower per hour ...	20	...	12·7

From Table I it will be seen that the weight of the machinery was almost halved. The steam consumption at full power was reduced by approximately 25 per cent and the steam consumption at cruising power was reduced by approximately 36 per cent.

Boilers.—The factor which contributed more than any other to this reduction in machinery weight was the boiler design, and I was fortunate to be associated with a number of trials of Admiralty boilers during this period, including those for H.M. ships "Kent," "Sussex," "Active," "Ilex," "Javelin," "Tiger," and "Diamond." In the case of "Ilex" we tested two boilers, one of the La Mont forced-circulation type and one of the Admiralty three-drum type. The Admiralty agreed that the trials of the latter should be continued to endeavour to find the "end-point" of the boiler. In order to ensure an adequate supply of combustion air at a sufficient pressure we used six turbo-driven forced draught fans in two banks of three each in series, and I can well remember running the final trial with the overspeed governors on the turbines tied up with copper wire, in order to get the air pressure required in the stokehold, which was about 18in of water gauge.

The principal advances in Admiralty boiler design which took place over the period between the end of the 1914–18 war and the end of the 1939–45 war may be briefly summarised as follows :—

(1) In the case of cruiser boilers an increase in pressure from 250 lb to 400 lb per square inch and an increase in steam temperature from 605 deg. to 700 deg. Fah.

(2) The substitution of Melesco type superheaters for the Admiralty U-tube design.

(3) An increase in the capacity of individual oil burners from 900 lb to 2100 lb per hour.

(4) The elimination of the straight tubes of the old Yarrow design and their replacement by curved tubes to accommodate larger superheaters.

(5) An increase in forcing rate of the boiler, i.e. the oil burnt per square foot of radiant heating surface. This required an increase in the depth of the tube bank from seventeen or eighteen rows to twenty or twenty-one rows to give approximately the same temperature of funnel gases.

(6) An increase in internal diameter of the fire row tubes from 1¼in to 1¾in and a reduction in diameter of the outer rows from 1¼in to 1in.

(7) An increase in the diameter of the steam drum from 50in to 56in to give a larger steam space and to accommodate the increased number of rows of tubes.

(8) The adoption of baffles or feed augmenters between the tubes in front of and behind the superheaters to improve the circulation.

(9) The adoption of external downcomers further to improve the circulation at the higher forcing rates.

(10) The elimination of riveted drums, first by the use of forged drums with ends riveted in, and more recently by the use of all-welded drums.

(11) The use of air heaters to increase the boiler efficiency particularly at cruising powers. In some vessels the air heaters were partially bypassed at higher powers.

(12) The use of gilled tube economisers as an alternative to air heaters to increase the boiler efficiency.

Towards the end of the 1939–45 war the Admiralty decided to increase the steam conditions in British destroyers to bring them into line with those which had been used for some time past in American destroyers. The steam conditions finally decided upon for the "Daring" class destroyers were 650 lb per square inch pressure and a temperature of 850 deg. Fah. In order to safeguard the turbines during working-up conditions, and when manœuvring, it was decided to fit two furnace boilers, either of Babcock and Wilcox or Foster Wheeler type, so that the steam temperature could be controlled over a wide range.

Turbines.—In the 1920s there was keen competition between the Parsons reaction turbines and the Brown Curtis impulse turbines. Considerable troubles were, however, experienced with blade failures in impulse turbines owing to synchronous vibration of the blades and turbine discs, which were not fully understood at that time. With the exception, therefore, of the cruisers "Australia" and "Canberra" and some of the "A," "B" and "F" class destroyers, most of the vessels built between the end of the first and the end of the second world war were fitted with reaction or impulse reaction turbines. With the "Kent" class cruisers the high-pressure and low-pressure turbines were of the all-reaction type, the high-pressure turbines being fitted with three cruising reaction stages. Trouble was experienced in service with these stages, owing to overheating of the blading, unless sufficient pressure drop were maintained over the stages to ensure an adequate steam flow. The only impulse blading in these vessels was the one three-row astern wheel fitted in the same casing as the low-pressure ahead blading. At about this time Parsons introduced their "end-tightened" blading in the high-pressure turbines.

Owing to the troubles experienced with the cruising reaction stages, the Admiralty reverted for a time to cruising turbines geared to the main high-pressure turbine rotor shafts, a similar arrangement to that which had been adopted in a number of vessels in the 1914–18 war. In the later 1930s the cruising turbines were again abandoned, and improved consumptions at cruising powers were obtained by the use of a two-row impulse wheel in the high-pressure turbine with groups of nozzles controlled by valves. With the use of higher steam pressures and temperatures and higher turbine revolutions the use of brass blading was abandoned in favour of stainless steel or Monel metal.

The standard Admiralty practice up to 1939 was to make the ahead end of all low-pressure turbines of cast iron, but the early days of the 1939–45 war soon showed up the inability of cast iron to withstand the shock due to underwater explosions. In order not to overload the steel foundries by making these of cast steel, it was decided to fabricate all future low-pressure ahead turbine casings by welding, and these proved very successful.

In the "Daring" class destroyers, to which reference has been made above, the Admiralty decided to fit three different designs of turbine in order to get direct service experience of the various types available. These were :

(1) An impulse-reaction high-pressure turbine and reaction low-pressure turbine.

(2) All-impulse, high-pressure turbine and all-reaction, low-pressure turbine.

(3) All-impulse, high-pressure and low-pressure turbine.

In these latest destroyers the nozzle control valves in the high-pressure turbines are opened in sequence by a camshaft operated through gearing by the main manœuvring

handwheel. This obviates the tendency of the ship's staff to keep more nozzle valves open than necessary, in case they are called upon for a sudden demand for increased power. In the turbines for the "Daring" class destroyers, the Admiralty finally discarded the practice of using cast-in nozzle plates in favour of building them up from accurately machined segments. This practice had been in use for a number of years in the more important merchant ships and for land turbines. The first vessel for which I was responsible which had fully machined nozzle plates was the "Queen Mary," which was fitted with them in 1937.

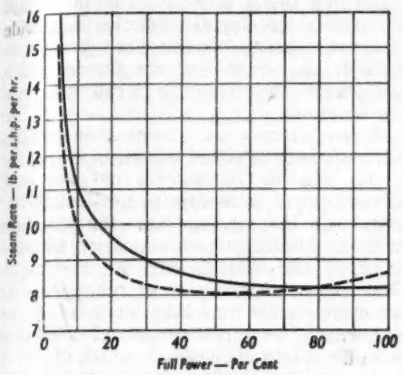


Fig. 1—Steam consumption curves

Towards the end of the 1939–45 war the main machinery contractors to the Admiralty came in for considerable—and, in my opinion, somewhat undeserved—criticism because of the much lower consumption of American naval vessels at cruising powers, compared with British vessels. This was principally due to two factors (*a*) the higher steam conditions adopted by the American Navy, and (*b*) the fact that the American turbines were designed for maximum efficiency at approximately 50 per cent of full power, instead of at full power, as were the British turbines, in order to achieve the very low machinery weights which were specified by the British Admiralty. Designing for the latter conditions has, of course, the effect of keeping down the size and, therefore, the weight of the boilers, piping, auxiliary machinery, &c., but the result is a higher consumption under cruising conditions, and therefore a reduced radius of action compared with the American vessels. The effect of designing turbines for the two different conditions is shown in Fig. 1.

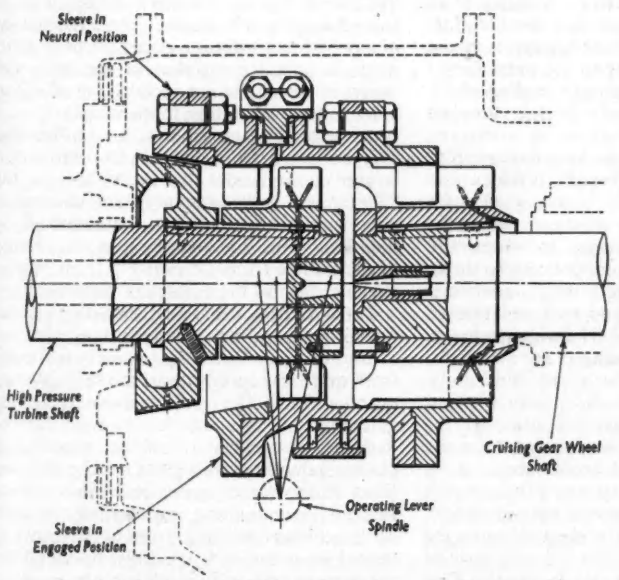


Fig. 2—Combined friction and dog-clutch for cruising turbine

Necessity is the Mother of Invention

It has been my experience in engineering that once the necessity for something arises it is usually comparatively simple to find the answer. I should, therefore, like to describe briefly three ideas—they can scarcely be called inventions—which I developed in connection with marine engineering.

Cruising Turbine Clutch.—I referred earlier in this address to the trouble which was experienced around 1930 by the Admiralty owing to the overheating of the cruising reaction stages in the high-pressure turbines. As a result of this the Admiralty decided to revert to the separate cruising turbine. This has many advantages, but one of the serious disadvantages in the old days was, that in order to engage the cruising turbine it was necessary to stop the main machinery. This is, of course, a very dangerous procedure in wartime. Rear-Admiral J. B. Sidgwick, or Commander Sidgwick as he then was, the inspector in charge of destroyer machinery at the Admiralty, asked whether someone could produce a clutch which could be engaged without having to stop the main engines. It occurred to me that this might be done by using a friction clutch for synchronising the two shafts, and then to engage the ordinary dog-clutch. It was rather a crude form of the synchromesh gearbox as it is known in motor-cars to-day. Fig. 2 shows a sectional arrangement of this combined friction and dog-clutch, which was fitted to the cruising turbines in the "E" class destroyers, and most of the "F" class destroyers built in the early 1930s, and proved quite successful.

Gland Evacuation System.—The Admiralty found in the 1939–45 war that steaming under war conditions, particularly in destroyers with the scuttles closed, living conditions for the engine-room personnel became almost unbearable owing to the constant leakage of steam from the turbine glands. I therefore sketched out a system, shown in Fig. 3, on the proverbial back of an envelope, in which an additional outer pocket on the turbine glands was connected to a small steam ejector, so that a very slight vacuum was created between this pocket and the engine-room. This had the effect of completely preventing any escape of steam to the engine-room. The steam from this ejector was condensed in a small separate ejector condenser which also functioned as an additional feed heater. The Admiralty agreed to try it out in two destroyers and it was found in service that not only did this arrangement prevent leakage of steam to the engine-room and improve the habitability, but it also had the effect of halving the amount of make-up feed required. This system was subsequently fitted to all new naval vessels and to most merchant vessels.

Flexible Shaft Bulkhead Gland.—In the 1939–45 war it was frequently found that owing to the distortion of bulkheads and the bending of shafts caused by underwater explosions, the ordinary shaft bulkhead gland ceased to function, and serious leakage of seawater occurred from one compartment to another. I therefore sketched a gland (Fig. 4) which incorporated a spherical bush which would run on the shaft, and also slide in the housing attached to the bulkhead. The whole gland was packed with grease. In order to test one of these glands, it was fitted on the side of a tank filled with water, and a short length of dummy shaft was run in the gland. A small wedge piece was inserted between the faces of the coupling on this shaft and another shaft which was driven by V-belts from an electric motor. This gave the effect of running a bent shaft in the gland, and it was found that under these conditions there was virtually no leakage.

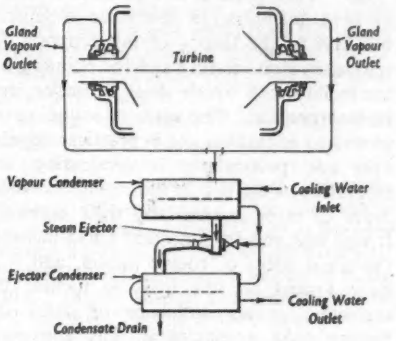


Fig. 3—Gland evacuation system

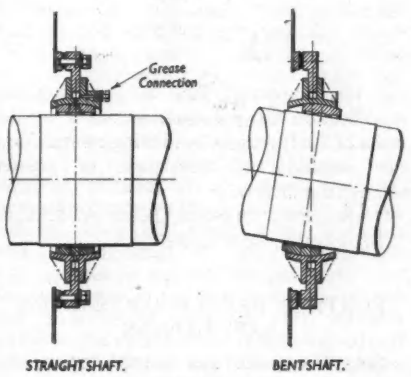


Fig. 4—Flexible shaft bulkhead gland

(To be continued)

Dual Air Brakes.—In our account of the Commercial Motor Show we referred to the use of duplicated pneumatic systems to safeguard vehicles against complete power brake failure (October 5, 1956, page 473). We have now received from the Westinghouse Brake and Signal Company, Ltd., 82, York Way, King's Cross, N.1, an account of its dual air brake system. Separate reservoirs are provided for the two systems, and a dual valve with compensating lever operation controls the brakes: lack of pressure in either section erects a warning signal. The reservoirs are rendered independent by check valves in the supply lines, there being a single unloading and safety valve at the compressor. The reservoir for auxiliary services is fitted with a charging valve to prevent it accepting air needed by the brake systems, and a limiting valve providing reduced pressure for, say, a pneumatic gearbox.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

RESONANCE STRESS TESTING

SIR,—I am grateful to Mr. R. P. N. Jones for his contribution in your issue of September 21st to the theory of my proposal for resonance stress testing and for pointing out the facility with which shear deflection may be incorporated. The value of including the secondary effects lies not in practical application nor particularly in evaluating any laboratory tests, but in indicating the small order of error involved by their omission. It was with this in mind that I had included the small effect of rotary inertia, and it is quite logical on this basis to include the somewhat greater influence of shear deflection. At a maximum, this correction could amount to about double that for rotary inertia, being related to it by the factor E/k^1G. In the case of the strut in example (*b*) of my article, the two effects combined modify the result by less than $\frac{1}{4}$ per cent.

For the sake of mathematical completeness, the values of α and γ should be amended to :—

$$\alpha=\left\{\frac{P-mk^2\omega^2-\frac{Emk^2\omega^2}{k^1G}}{EI}\right\}L^2$$

and

$$\gamma=L^2\omega\sqrt{\frac{m-\frac{m^2k^2\omega^2}{k^1aG}}{EI}}.$$

I fear, however, that by including the modification to γ (which amounts to the order of 10^{-7}) I might be inviting comment on the exclusion of corrections of greater relative significance !

BERNARD BRAMALL, B.Sc., A.M.I.C.E.

Manchester, October 8th.

FURTHER FRENCH LOCOMOTIVE EXPERIENCES

SIR,—I have only just had the opportunity of reading Mr. Livesay's latest series of articles on the above subject, and write to thank both him and you for these very interesting and informative contributions. Evidently " age does not wither nor custom stale " either your contributor or his work, which I have enjoyed for upwards of twenty years. They are always fresh and racy ; as I said once before, they *live*, making one feel in the company of the engines he describes so vividly, as though one were there too, and that is the secret of the pleasure one gets from reading them.

Another attraction is that he is dealing with fine and unusual engines with which we in this country are unacquainted, and often ill-informed, doing work which ours have seldom, if ever, equalled, and are certainly not equalling now. Lengthy and minutely detailed description of the work being done by our now mostly ageing and familiar engines, however meritorious it may be, is apt to be tiresome, as we know all about it already, and it is at any rate no better than was done twenty years ago, if as good. There is nothing more to be said about them.

Granted that the steam locomotive is nearing the end of its long and honourable day in Britain, it will be with us for a considerable time yet, and we can learn a good deal from those across the Channel, and from French operational methods and equipment, which Mr. Livesay portrays so well. His articles paint a bright picture of the way things are done over there ; an overall picture, not spoilt by a mass of non-essential detail only of interest to people who are no doubt already fully informed on these points. The general reader does not want it.

Imitation may be the sincerest form of flattery, and there have been imitations, but I repeat what I have already said in your journal, that in my opinion Mr. Livesay's articles are inimitable.

JAMES STOKES

Wembley, October 14th.

Literature

Cavitation in Hydrodynamics. H.M. Stationery Office, London. 1956. Price £1. 10s.

No less than twenty-two papers are included in this impressive volume, which records the proceedings at a Symposium held at the National Physical Laboratory in September, 1955. The majority of the papers are by authors from Great Britain and U.S.A., with welcome contributions from Austria, Denmark, Japan, Switzerland and the U.S.S.R. The Symposium attracted delegates from fifteen countries testifying to the wide interest in the subject of cavitation or boiling which has developed intensively during the last decade or so. It may come as a surprise to the engineer who for so long has grappled with the difficulties of water turbines and to the naval architect preoccupied with marine propellers, to discover that the problem of cavities formed in water and other liquids is now also of concern to those, among others, associated with underwater explosions, oil systems and rockets launched into water from aircraft. The wider technical applications have encouraged an impressive series of researches which are continuing. Many papers deal with the purely physical and mathematical aspects, and although the busy engineer may be disappointed by the lack of really firm guidance in some of his problems, it is clear that the fundamentals and the causation are now closely identified. Reliable information is presented as to the inception, growth, decay and collapse of cavities in a rapid periodic sequence. One important practical upshot is not completely clear in that cavitation damage is still variously ascribed to impingement of collapsing bubbles or to corrosion fatigue with galvanic action or to shock waves and with different emphasis according to the particular investigation concerned. This emphasises, not for the first time, that the reason for any particular case of damage may only be correctly diagnosed by the co-operation of the engineer, physicist and chemist.

The propeller or turbine designer might well recoil from one author who claimed that collapse pressures up to 30,000 atmospheres had been measured, but reflect without complacency that such heavy pounding could hardly have been sustained in practice by the material of the item concerned. This and other experiment results underline the importance of elucidating scale effects in laboratory work which at present limit confidence in the application of the results of some of the elegant researches described. Viscosity, surface tension and gaseous or solid nuclei, are among the factors which complicate the issue and call for real clarification.

It now seems established that cavities form around nuclei and one claim is that the nuclei may be air bubbles of only one-thousandth of a centimetre in diameter or even more minute, and that the variation of cavitation inception is associated with the different size and quality of the nuclei. There is no confirmation or otherwise that air cavity nuclei have been identified in the sea or that the size is so minute. There seems a doubt as to the tension which " pure " water can sustain, but 10 atmospheres previously obtained is now confirmed when the water is in contact with steel. The experiments of another author indicate that " pure " water can, in fact, sustain considerable tension without cavitation which probably explains the high tensile stress which is not necessarily related to the pressures at which cavities can be formed in practice. A remarkable series of photographs of propeller cavitation on a destroyer and on a fast patrol boat are included in one paper and these, in conjunction with model tests described by another author, bring home the necessity of simulating in a model experiment the mixed flow at the stern of the ship, if real advance is to be made. There is evidence of a pronounced change of cavitation pattern with the angular position of the propeller blades if the shafts are inclined, resulting in more intense cavitation momentarily.

An interesting example of the lessons that may be learnt from a small laboratory test is the confirmation that scratches on the "Plexiglass" walls of a very small channel in one experiment lead to the formation of air bubbles. This by analogy can be related to the bubble formation arising from minute irregularities on the surface of a propeller.

Three papers deal with two-dimensional flow on foils and struts and the determination of the forces and the requirements for shape from quite low speeds up to the fully cavitating condition. The results provide interesting guidance to the propeller and turbine designer, although it would be helpful if a clearer summary were given of the implications of the rather specialised mathematics. Impressive equipment is described in some of the papers ranging from a large water tunnel in a building specially provided for the purpose to small channels accommodated on a laboratory bench all equipped with refined instruments. High-speed photography, powerful stroboscopic illumination, electronics, acoustics and magnetostriction are all called into play. The vigorous discussion as to the value of the expensive resorbers provided with some cavitation tunnels revealed support for the view that the addition is not really necessary for large equipment. The indispensable value of photography is evident from the splendid pictures taken at the remarkably fast rate of 1,000,000 per second with a high degree of realisation. This brought to light the life history of individual bubbles in a cavita-

tion pattern which appeared by direct observation to be no more than a blurred mass.

The enterprise of the Director, National Physical Laboratory, in arranging this first Symposium on Cavitation has been amply rewarded by the splendid quality and variety of the papers and the virile discussion. Talented young men vied with established authority to dispose of the complicated problems with a zeal and ability that augurs well for the future. It is hoped that their efforts will be directed to the qualities of natural water as found in the deep seas, lakes and rivers rather than to the " pure " water which has almost monopolised attention so far. The variety of symbols and cavitation parameters could be co-ordinated into a common nomenclature with advantage to the reader.

The volume has been well produced with clear diagrams and photographs and with refreshing economy for a book of nearly 500 pages, brimful of valuable and thought-provoking information. Most papers are supported by a generous bibliography so that the book may well come to be regarded as a unique standard of reference on the subject, although the value for this purpose would have been enhanced if an index had been included.

Calder Hall. By KENNETH JAY. Methuen and Co., Ltd., 36, Essex Street, London, W.C.2. Price 5s.

THIS book, which was written by a member of the staff of the U.K. Atomic Energy Research Establishment, Harwell, with the official blessing of the U.K. Atomic Energy Authority, tells the story of Great Britain's first nuclear power station. It is a delightfully lucid account, written in simple, non-technical language, which should be readily intelligible to the layman. To the technical reader it should also be useful as an introduction to the much more detailed studies which are to be found, for example, in the proceedings of the British Nuclear Energy Conference. Calder Hall is in a sense the springboard for Great Britain's nuclear power programme and it will form a basis for the design of the gas-cooled reactors for the power stations in the first stage of that programme. Calder Hall, indeed, is the beginning of nuclear power on a commercial scale, and the reader has a sense of being " in at the beginning," as Kenneth Jay starts his narrative by describing early ideas about power generation, as a natural development from the graphite-moderated, gas-cooled pile Bepo at Harwell.

As long ago as 1947, the engineers at Risley were exploring the possibilities of improving heat transfer by enclosing the uranium rods in finned cans ; they were comparing hydrogen, helium and carbon dioxide as coolants ; and they were developing the idea of enclosing the reactor core in a shell containing the coolant under pressure. Private industry first came into the picture early in 1948, when three firms—Parolle Electrical Plant Company, Ltd., C. A. Parsons and Co., Ltd., and Babcock and Wilcox, Ltd.—were invited to study the problems of generating steam for power production in a gas-cooled reactor of the kind under consideration. Soon ideas had been clarified to such an extent that, at a conference held at Harwell in September, 1950, an estimate could be given of the cost of power generation from a gas-cooled reactor—less than a penny a unit. The prospects were sufficiently bright to justify technical studies for the building of a plant from which operating experience could be gained and costs could be assessed realistically. A study group was therefore formed at Harwell in January, 1951, to examine the feasibility of a nuclear plant for producing electrical power and plutonium simultaneously from natural uranium. The only predetermined condition, the use of natural uranium, implied a thermal reactor ; all the remaining parameters, depending on the possible choice of moderators, coolants and steam cycles, had to be evaluated. How all the variables were examined, how the choice was made of graphite for the moderator, and carbon dioxide for the coolant, how a 2in wall thickness was accepted for the pressure vessel and how a dual pressure steam cycle was adopted—these, and all the other relevant considerations in the evolution of the design of the Calder Hall station are admirably related in Kenneth Jay's book. The story ends, appropriately, with a glimpse into the future as foreshadowed by Great Britain's ten-year nuclear power programme. It is a pity that there is no index, for a book such as this, short though it is, deserves one.

Selected Combustion Problems, II : Transport Phenomena ; Ignition ; Altitude Behaviour and Scaling of Aero Engines. Butterworths Scientific Publications, Ltd., 88, Kingsway, London, W.C.2. Price 90s.

A PREVIOUS volume under the same title was published in 1954, summarising papers and a discussion at a colloquium which had been held at Cambridge, England, in 1953. The present volume deals with a similar colloquium which was held at Liége in December, 1955. These colloquia were organised by the N.A.T.O. Advisory Group for Aeronautical Research and Development.

The papers are divided into groups under the headings : Aircraft Engines and Fuels, Ignition and Flammability, Transport Properties, High Altitude Combustion Problems, and Similarity, Scaling and Fundamental Parameters in Combustion. There is a joint discussion at the end of each group. A proportion of the papers and discussions are in French, but papers written in French are summarised in English and vice-versa.

It can be stated at once that although the papers deal exclusively with aeronautical problems they will be found useful to a much wider range of industry. There is a refreshing absence of jargon and, in some of the papers, at any rate, a down-to-earth practical approach which enables the ordinary engineer both to follow the line of argument without difficulty and to see how far it applies to his own particular problem. This outlook is well-illustrated by the following comment from a well-known chemist in one of the discussions.

" . . . Hydrocarbon composition in practical petroleum fuels is a matter of secondary importance only ; its effect on combustion efficiency and stability is swamped by the aerodynamic and physical factors which determine the temperature level of the reaction. . . . We have spent long enough already looking for chemical influences in gas turbine combustion and it is high time now to give up what has proved to be an unrewarding pastime."

The papers by S. L. Bragg and J. B. Holliday on " The Influence of Altitude Operating Conditions on Combustion Chamber Design," and by B. Way on " Combustion in the Turbojet Engine," are especially good expositions of the problems currently facing the designers of combustion equipment for jet engines, and it will come as a shock to those outside the aircraft industry to realise that in high altitude flight combustion efficiencies of the order of 60 per cent or even lower may have to be accepted. This is due partly to the reduced reaction rates at extremely low pressures and partly to the difficulty in designing equipment which will operate satisfactorily over the very wide range of conditions between full power at sea level and cruising at 70,000ft. In this respect it is somewhat surprising that so little effort has been made to develop means of varying the proportions of combustion and dilution air. Admittedly, it is a difficult problem, but is it any worse than that of jet reversal, which, judging from the recent flying display at Farnborough, has now been successfully solved ?

The cost of research in connection with defence and military requirements now runs into astronomical figures and is a heavy burden on the taxpayer. It is fortunate, therefore, that much of this work can usefully be applied to peaceful ends, and it behoves everyone to take the utmost advantage of such results and information as can be made public. In this respect the present volume performs a very useful service.

Jig and Fixture Design, by P. S. HOUGHTON, A.M.I.Mech.E. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 36s.

ONE of the essential requirements for the economic production of interchangeable components is the provision of efficient jigs and fixtures which combine accuracy with simplicity of operation by semi or unskilled labour. All designers have their particular methods of obtaining these ends but there are certain basic principles which must be considered. The aim of the author of this book has obviously been to present students and others concerned with jig and fixture design with the essential principles and requirements, together with a selection of examples, which will provide a useful basis and guide in their work. The book opens with chapters on production planning and jig and fixture design ; it then deals in fuller detail with different methods of clamping, indexing, jigs and fixtures for drilling, tapping, boring, milling, broaching, grinding and concludes with useful notes on dimensional data and standards and on motion study and design. Both instructors and students will find a series of questions and problems based on the information given in the various sections of interest and value. The book provides a useful companion to the other well-known works by the same author on press tool practice.

Books Received

Frequency Modulation Receivers. By J. D. Jones. George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 21s.

V.H.F. Television Tuners. By D. H. Fisher. George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 21s.

Electrostatic Precipitation in Theory and Practice. By H. E. Rose and A. J. Wood. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 17s. 6d.

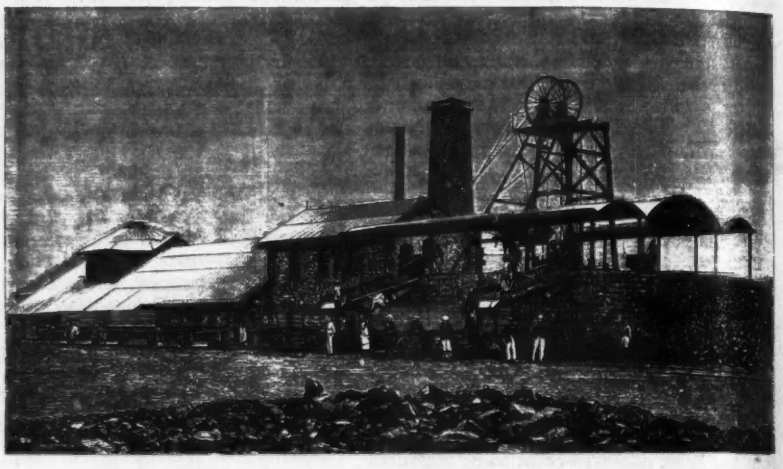
Fatigue of Metals and Structures. By H. J. Grover, S. A. Gordon and L. R. Jackson. Thames and Hudson, Ltd., 30, Bloomsbury Street, London, W.C.1. Price 35s.

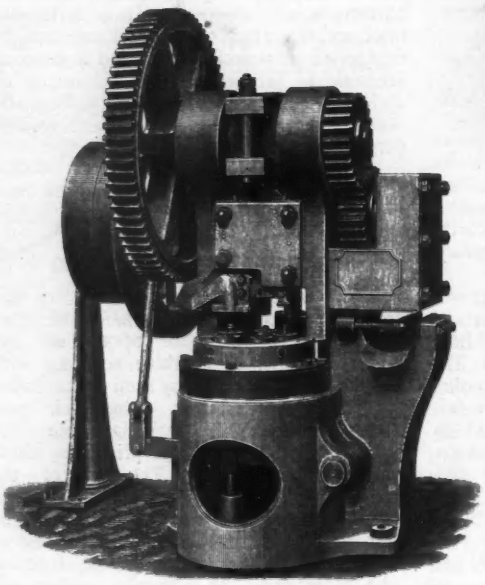
Mechanical Vibrations. Fourth edition. By J. P. Den Hartog. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 67s. 6d.

Directory of Railway Officials and Yearbook, 1956–57. Compiled under the direction of the editor of the *Railway Gazette*. Tothill Press, Ltd., 33, Tothill Street, Westminster, London, S.W.1. Price 40s.

ENGRAVINGS OF 1877

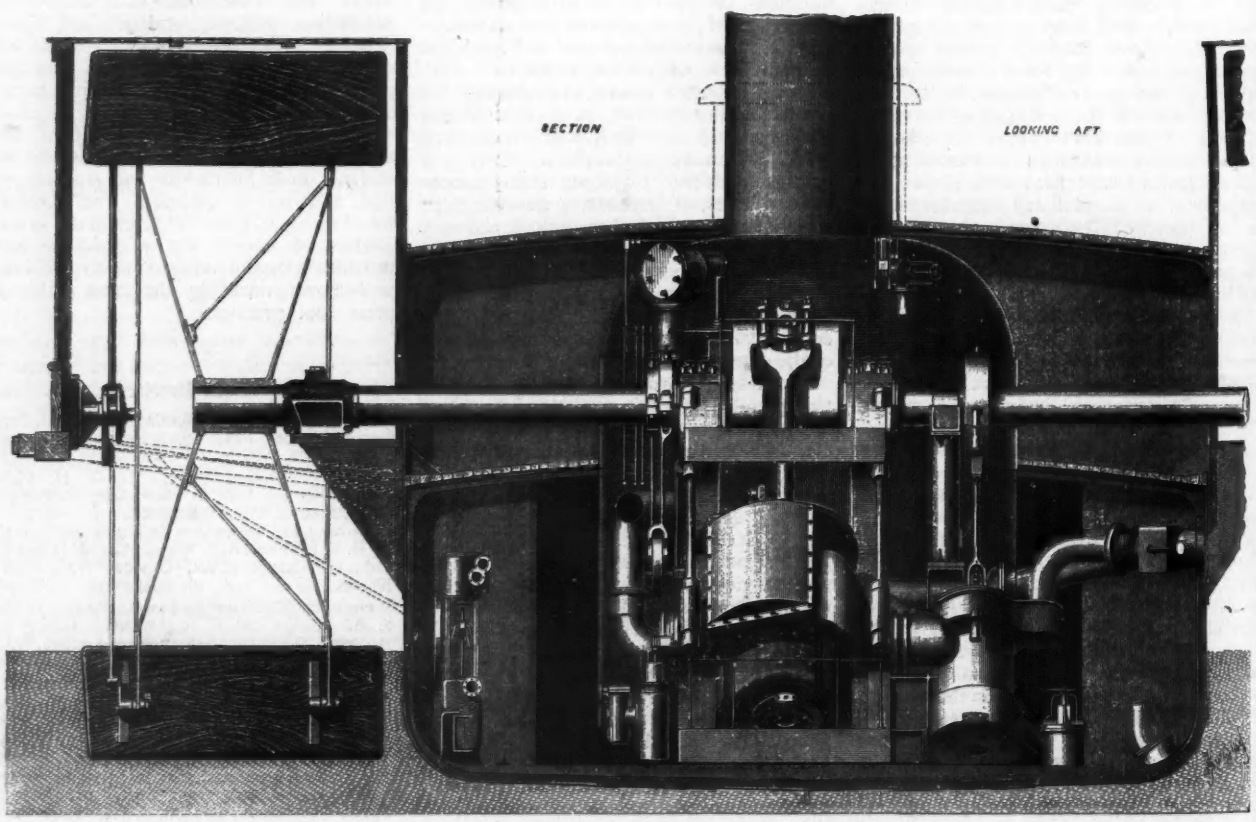
The right-hand engraving, reproduced from our issue of October 26, 1877, illustrates the Warora Colliery, Central India. The colliery, which at that time was "drawing 500 tons a week," had been developed for the government by Mr. Walter Ness, a British mining engineer. The work had taken four years, two shafts having been sunk to a depth of 210ft. There were two winding engines, "capable of drawing 300 or 400 tons a day," and they had "an iron pit-head frame with wiredrawing rope." Two other engines of 18 and 25 h.p. worked "a couple of 12in pumps of 5ft to 6ft stroke."





The rivet making machine, illustrated by the left-hand engraving, was a product of W. Collier and Company, Salford, Manchester. A description of the machine published in our issue of July 27, 1877, says: "the header or 'snap' is carried in a vertical slide, which has a reciprocating motion imparted to it by an eccentric shaft driven by suitable gearing. The dies, five in number, are carried in a circular table and brought successively under the header by an intermittent feed motion, which not only moves the table until the die is perfectly central with the snap, but locks it, and holds it firmly whilst the rivet is headed, so that should the iron get more to one side than the other, it will right itself by pressure and not spring the table and form a crooked head."

The engraving below, which is reproduced from our issue of August 17, 1877, shows the engines of the Clyde steamship "Lord of the Isles." The steamer was built and engined by D. and W. Henderson and Company. The engines, our article says, "will prove a special source of attraction for passengers; enclosed only by a handsome bronzed railing, their working is exposed to full view." The description goes on to explain that "the engines are surface condensing, with diagonal oscillating cylinders, both piston rods connected upon one crank pin; the cylinders are 46in diameter, 5ft 6in stroke, revolutions 46 per minute." The working pressure of the boilers—there were two—was 50 lb



International Motor Show

No. II—(*Concluded from page 555, October 19th*)

IN our report last week we dealt with British cars, either exhibited at this year's show for the first time, or those with major modifications since 1955. Turning now to foreign exhibits, we note that the American manufacturers are again represented in full strength; no less than nineteen firms are displaying an impressive collection of mainly new models made in U.S.A. and Canada, not intended for sale here, but in such overseas countries as have no import and currency restrictions.

From the fact that overall dimensions and engine output are still on the increase, one may deduce that U.S.A. is occupied with designing almost entirely for the home market. This would seem to indicate that it is becoming less concerned with the direct sale of her cars abroad, leaving it to her subsidiaries in this country and in Germany to manufacture and supply cars to those markets for which the American type car is unsuitable.

Fig. 8—The Volvo P.V.444 sports saloon will attain 90 m.p.h.

Contrary to the British policy of not making changes "for the sake of change," the Americans believe in the sales appeal of new designs, even if the alterations involved apply almost entirely to styling. Most of the 1957 American models will make their first appearance later this year, but the cars exhibited at Earls Court give some indication of the direction in which technical progress and styling is likely to develop. For some time, American body style has been influenced by continental, particularly Italian, examples. This tendency has markedly contributed to their elegance and æsthetic appeal, though in some cases the graceful lines of an originally pleasing design have been obliterated to some extent by the heavy ornamentation of the air-intake louvres and the bumpers. The steeply raked and sharply curved back windscreen is to be seen on all of the latest American cars; other styling features include large wrap-round rear windows, transparent roofs, and long-flowing lines resembling stabilising fins, at the rear wings. The finish and equipment of American cars is excellent, and, measured by European standards, almost lavish; air conditioning, heating and power operation of folding roofs, window winders and seat adjustment are standard equipment in higher priced cars.

No drastic alterations are apparent in the mechanical layout which is characterised by high-powered V.8 engines and automatic transmissions in chassis of mainly orthodox design. There is a general tendency to employ smaller wheels, the 14in wheel gaining prevalence as against the present 15in wheel.

Automatic transmissions are universally accepted for the top and medium-priced makes and the manual gear change is obsolete in all but the lowest priced cars. The number of cars with power-assisted steering and braking has increased and engines of less than 3 litres capacity are virtually dying out. Most of the modern V.8 engines are using compression ratios of more than 9 : 1, as high-octane petrol is taken for granted in America, and because the automatic transmission effectively limits excessive full-throttle operation of the engine.

There are some significant chassis modifications common to the new cars made by the Chrysler Corporation. The former conventional coil spring of the front suspension has been replaced by a modified system employing lower single-arm wishbones at each side, directly connected to longitudinal torsion bars, and ball-joint pivots at the top and bottom. At the rear the semi-elliptic leaf springs are mounted outboard of the frame to provide a wide roll base, and the axle is mounted forward of their mid-point to reduce torque hop and brake dip.

One of the more interesting American cars, already mentioned as the "dream car" of to-morrow, is the Buick "Centurion," of General Motors, a two-door coupé driven by a 325 h.p., 5·25-litre, V.8 engine, and a variable-pitch "Dynaflow" transmission. A noteworthy feature of this car is the fitting of an electronic rear view device, consisting of an enclosed circuit television camera enclosed in the trunk which relays the image to a 4in × 6in screen in the middle of the dashboard. Two simple controls allow the driver to adjust for contrast in brightness. The steering column is located in the centre line of the car and is connected with the wheel at the driver's position by a cantilever arm to provide added leg room for the driver. The production Buick also shown at the same stand, is a four-door saloon, powered by the over-square 5·3-litre engine common to all Buick models, and in this case gives 255 h.p. at a compression ratio of 9·5 : 1. Also at the stand of General Motors is the Chevrolet, General Motor's best seller, which is available either with a 3·9-litre, six-cylinder, or with a V.8, 4·3-litre engine. The latter version, with a compression ratio of 9·25 : 1, has an output of 210 h.p. at 5200 r.p.m. The automatic transmission employed for Chevrolet cars is the "Power-Glide" transmission employing a three-element torque converter in conjunction with a two-speed epicyclic gear train.

Two examples of the Ford range of American and Canadian cars are exhibited, both newly introduced 1957 models. The more interesting of these two cars is the "Thunderbird" two-seater sports car, fitted with a 5·1-litre V.8 engine having a compression ratio of 9·7 : 1 and developing 245 h.p.

The 1957 Studebaker "Golden Hawk" two-door hard-top saloon has a super-

Fig. 9—The four-wheel-drive Rover gas turbine car has a glass-reinforced resin body

charged V.8 engine of 4·7 litres capacity, and is claimed to develop 290 h.p. The centrifugal blower is belt-driven and variable speed is obtained by opening and closing the sides of the respective vee pulleys electromagnetically to vary its effective rate.

The French automobile industry in this year's show is again represented by the "Big Four" Renault, Simca, Citroen and Peugeot, which account for 90 per cent of the French production. The most interesting French cars, the Citroen DS 19 and the

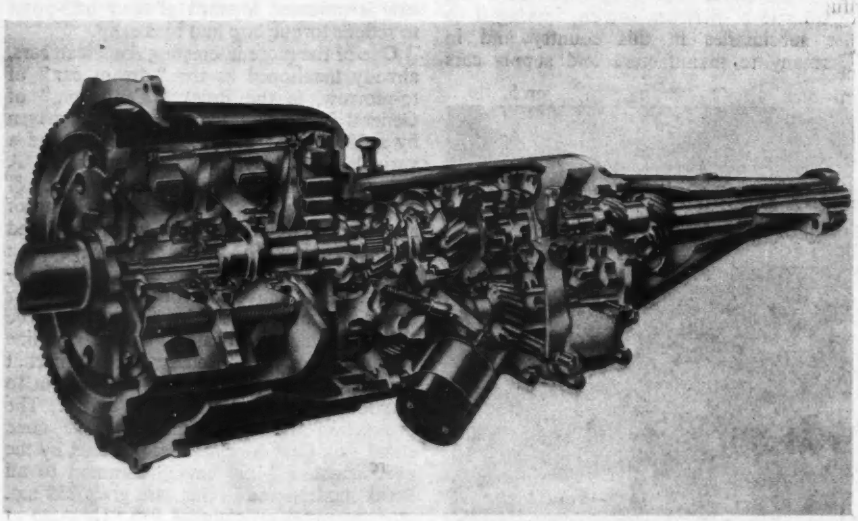


Fig. 10—The Smith's transmission provides three forward speeds and reverse; changes are completely automatic

2 c.v., are well known in this country, the former having been fully described in our issue of October 21, 1955. It may be recalled that the main feature of the DS 19 is the extensive use of hydraulic pressure, not only for the control of the pneumatic suspension, but also for the servo-assistance of steering, braking and for the operation of the clutch and gear change. A simplified model, the ID 19, recently added to the French Citroen range, is basically similar to the DS 19, but has a less powerful engine and uses hydraulic power only to control the suspension; it will not be on the British market this year and is not being shown at Earls Court.

A car which this year makes its first public appearance in this country is the Renault "Dauphine," a description of which was contained in our report on the Geneva Motor Show of April 27, 1956. Since its introduction this spring, the car has become very popular and is reported to be produced now at the rate of 575 per day. Like the smaller 750 c.c. Renault, the "Dauphine" is a rear-engine car with a water-cooled 850 c.c. o.h.v. engine, a synchronised three-speed gearbox and all-wheel independent suspension.

No major changes are apparent in the 1·3-litre Simca "Aronde," a car which last year (together with the "Aquilon," basically similar to the pre-war V.8 Ford) commanded the biggest sales in France. Prominent among the cars representing German industry is a new Mercedes-Benz saloon type 190. Basically similar to the type 180, it has a new 1·9-litre overhead-camshaft engine, which develops 84 h.p. at 4800 r.p.m., i.e. 45 per cent more than the rather antiquated side-valve engine of the former type. Roomy and comfortable, but rather severely styled, the car has the well-known Mercedes features, such as the oil-water heat exchanger incorporated in the cylinder block, and the low-pivot rear swing axle.

At the stand of Volkswagen a saloon of Ghia design on a V.W. chassis repudiates the commonly held opinion that rear-engined cars do not lend themselves to an æsthetically satisfying styling.

An interesting example of a German miniature car is the Goggomobil, a two-door saloon fitted with a rear-mounted, air-cooled, two-stroke engine of 300 c.c. cylinder capacity developing 17 h.p. at 4800 r.p.m. The car is fitted with a four-speed gearbox, and the independent all-wheel suspension employs swing axles at the front and rear. Only minor changes are noticeable in the Italian cars shown by Alfa Romeo and Lancia. At the Fiat stand main interest focuses on the Fiat "Multipla" dual-purpose car, which, first exhibited at Brussels earlier this year, makes its first appearance at the London show. The car, which seats six people in moderate comfort, or, alternatively, provides a loading platform of approximately 19 square feet, has four large doors, a generous window area, and the equipment includes a built-in heating and ventilating system. In mechanical respects it is similar to the well-known Fiat 600 saloon, but employs coil springs and coaxial hydraulic dampers instead of the transverse leafspring of the latter. A fuller description of this interesting car has already been given in our report on the Geneva Show in THE ENGINEER of April 27, 1956.

The Swedish automobile factory A.B. Volvo, which at last month's Commercial Motor Show exhibited some interesting trucks, is now showing for the first time in this country examples of its motor-car production: one is seen in Fig. 8. The Volvo "Amazon" is a comfortable four-door saloon, powered by a four-cylinder 1·6-litre engine of 79·4mm bore and 80mm stroke, which develops 60 h.p. at 4500 r.p.m. It is of conventional design apart from the live rear axle, which is suspended by coil springs. The vehicle is built in integral all-steel construction; special attention has been given to make it, as far as possible, rustproof to withstand the extremes of Arctic winters. The Volvo two-seater sports convertible has a plastic body and a chassis frame of tubular steel construction. The engine, basically similar to that of the standard version, has a bore 4·4mm smaller, twin horizontal carburetters, and a hardened crankshaft running in lead-bronze bearings. With a displacement of 1·42 litres and a compression ratio of 7·8 : 1, it develops 70 h.p. at 5500 r.p.m., equivalent to an output of 50 h.p. per litre. In contrast to the standard version, which is fitted with a three-speed gearbox, the sports car has five speed ratios.

It has already been mentioned in our last week's issue that the majority of British motor manufacturers have refrained from altering their models to any great extent and have concentrated on modifications, mainly in the nature of pure refinements, which could be carried out without interfering with the steady flow of production. We referred in this connection to the various improvements in body styling and to the general tendency of increasing the specific output of engines by means of raising the compression ratio and, to a lesser extent, the engine speed. Some progress has also been made in the development of combustion chambers with improved anti-knock characteristics, and in the design of inlet manifolds to improve the gas-distribution, especially in six-cylinder engines. Engines of otherwise standard design, when used in sports cars, are generally fitted with two carburettors.

Apart from the increase of the cylinder capacity of the small B.M.C. engines, there appears to be no tendency yet to a more general increase in engine size. Apparently British designers have become accustomed for years now to developing small capacity high-speed engines, to comply with the restrictions of the old horsepower formula which formed the basis of taxation, and the experience of past years still influences present practice. However, should the present demand for fully automatic and

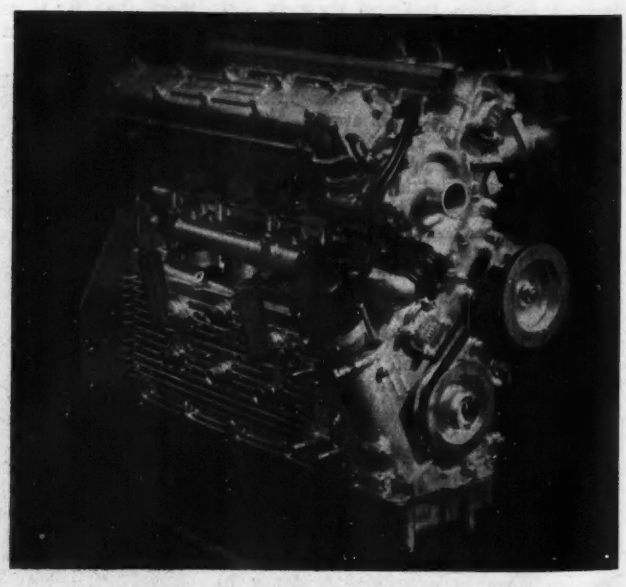


Fig. 11—Twin o.h.c. Coventry Climax engine of 1475 c.c. In the Formula II Lotus, two Weber carburetters are used

semi-automatic transmissions grow, it is quite feasible that the demands for higher torque at lower engine speed might well force our constructors to concentrate upon engines of increased capacity without sacrificing fuel economy.

The only new engine at the show is a Coventry Climax 1·5-litre engine which is making its first public appearance in a sports/racing chassis of Lotus Engineering Company. The engine, a four-cylinder unit of 81·2mm bore, and 71·1mm stroke, has a compression ratio of 10 : 1 and develops 140 h.p. at 7000 r.p.m., with a maximum torque of 108 lb-ft at 6500 r.p.m. The combined cylinder block and deep crankcase is of aluminium alloy with wet cylinder liners, and the fully counterweighted crankshaft runs in five main indium-plated lead-bronze bearings. The light alloy cylinder head has hemispherical combustion chambers with one inlet and one exhaust valve per cylinder arranged at an included angle of 66 deg. The valves are operated through inverted piston type tappets by two camshafts which are driven by a gear train at the front of the engine. The same gear train also drives the two scavenging pumps and the pressure pump for the dry sump lubricating system and the water pump which is located at the front of the timing drive cover. The engine will also be available for installation in sports cars, and when equipped with a starter and dynamo weighs only 280 lb, i.e. 2 lb per horsepower. It is illustrated in Fig. 11.

The design of suspensions on mass-produced cars has remained practically unaltered and so has the design of the orthodox types of clutches and gearboxes. The hydraulic operation of the clutch withdrawal mechanism is now almost universal, and there is an increased tendency towards fitting overdrive gearboxes as an optional extra to fast cars, especially sports models.

With the increased speed of modern cars, more attention has been paid by manufacturers to designing contemporary brake arrangements with the highest possible stability, maximum retarding power and fade resistance. The disc brake which had been evolved from the experimental stage for some time, could actually be adopted in private cars, but so far, remains confined to some fast sports cars. Progress has been made to ensure a constant clearance between the friction pads and the disc, as in the Lockheed brake, and improvements in servo-assistance have done away with any shortcomings formerly associated with this system.

The most prominent of all trends among British cars this year is the adoption of automatic and semi-automatic transmission devices in answer to the growing demand for ease of driving. That such a development should eventually come about was to be expected, but the sudden appearance of several systems of "two-pedal control" has come as a surprise. The availability in this country of the British-made Borg-Warner automatic transmission has, of course, stimulated manufacturers to adopt this system for cars of a suitable power/weight ratio. In these circumstances it was only natural that more attention should also be given to facilitate clutch and gear change operation by means of comparatively simple and inexpensive devices. At last year's show, the only system available in this country was the Lockheed "Manumatic" control which was optional equipment to the Armstrong-Siddeley "Sapphire 236." As this system was first shown to the public at the London Motor Show, 1952, and has been fully described in THE ENGINEER of November 14, 1952, it will be sufficient to recall that it has a speed control, added to the vacuum servos, which ensures that gear changes cannot be effected at other than the correct engine speed. The "Manumatic" control has since proved its suitability and is now available optionally for most of the 1·5-litre cars of the British Motor Corporation, i.e. generally speaking, for medium-priced cars in which a fully automatic gear, for technical as well as economical reasons, would not be justifiable.

Belonging to the same category of the centrifugal clutches with vacuum-operated withdrawal, there is the "Newtondrive" system, which, first introduced at this year's Commercial Vehicle Show and described in our report in THE ENGINEER of October 5, 1956 is optional equipment in the "Standard Ten" car.

All systems which affect the clutch engagement by centrifugal or electromagnetic action are definitely steps in the right direction, though the efficiency of this system depends entirely on the reliable working of the synchronising mechanism within the gearbox. Electromagnetically actuated friction clutches have been known in France for some time and have become a popular feature

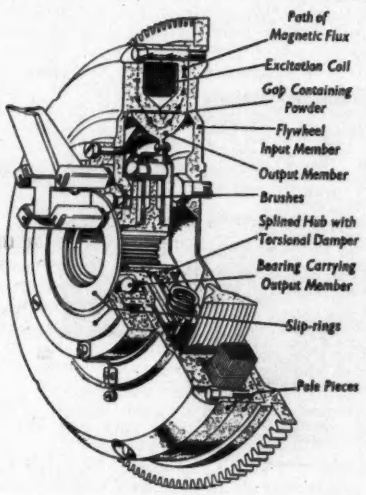


Fig. 12—Diagram illustrating functioning of Smiths' clutch

in the 750 c.c. and 850 c.c. Renault rear engine models. Another system, based on the use of a magnetic dry-particle clutch, has been developed for some time by the American Eaton Manufacturing Company. In this country S. Smith and Sons (England), Ltd., has carried out further development work, as a result of which a large number of prototype installations of such clutch units for motor cars have been made and tested under severe operating conditions for some considerable time. The clutch, though not yet fitted to any car at the show, is exhibited at the company's stand.

The clutch unit is of comparatively simple design and comprises a driving member which is coupled to the engine flywheel and contains an insulated electric coil and a driven member, splined to the intake shaft of an orthodox gearbox.

When the coil is energised by an electric current a radial flux is induced, which passes from the driving to the driven member through the magnetic power contained in the gap between these members. The flux has the property of solidifying the magnetic powei in such a way as to transmit the driving torque from the intake to the output member, the torque being almost directly proportional to the excitation current in the coil. This can be followed in Fig. 12.

The electromagnetic clutch has a number of advantages compared to the mechanically or centrifugally operated friction clutches and to the earlier types of electromagnetic friction clutches. As the friction coefficient of the ferro-magnetic power is independent of temperature up to about 600 deg. Cent., the torque capacity remains unaltered by changes of temperature. Further, as the torque is proportional to the current in the coil, it can be varied almost instantaneously from minimum to maximum and vice versa. When the clutch is fully energised there is no slip, and when the magnetic field has completely collapsed there is no appreciable drag. In this respect the clutch compares favourably with fluid devices, such as fluid couplings and hydraulic torque converters.

The immediate application of the magnetic powder clutch to the development of a two-pedal system has been effected by an electrically controlled system of switches incorporated in the gear change control in such a manner as to break the clutch excitation circuit automatically when the gear shift lever is operated. Smooth and progressive starting from rest is provided by using the voltage, rising with the rotational speed of the dynamo, to energise the clutch during the take-off. For gear changing a press button switch built into the gear lever breaks the clutch feed current and disengages the drive. There are two mercury switches in the system, sensitive to fore-and-aft accelerations, which reduce the excitation current when the car is not accelerating. This limits the value of the decelerating torque which the clutch can transmit and provides smooth down changes at light or closed throttle conditions.

Apart from the simple two-pedal system described above, the magnetic clutches can be used to advantage in a more elaborate fully automatic transmission. The latter system basically consists of two magnetic clutches connected to a three-speed and reverse gearbox of the orthodox layshaft type. The two magnetic clutch units are mounted one behind the other and have a common intake member, while the output members are mounted on separate coaxial shafts. The direct drive (with the first clutch engaged) is similar to that of a conventional transmission, but first and second gears are operated through the layshaft by exciting the rear clutch field coils. The layshaft is driven by a pair of constant-mesh gears from the rear clutch output member; the first and second gear pinions, which are integral with the layshaft, are in constant mesh with corresponding gears which are free to rotate on the main shaft unless locked to it by selection. Gear engagement is effected by a sliding muff on the main shaft, comprising two dog clutches and a simple baulk ring synchroniser, which is shifted into position by a solenoid. The excitation of the appropriate electromagnetic clutches and of the gear shift solenoid is obtained by the usual means of a speed responsive governor and the torque-responsive position of the throttle linkage. The complete assembly is seen in Fig. 10.

The Borg-Warner transmission has already been mentioned earlier in this report. In view of its almost universal adoption by British manufacturers, a more explicit description of its principle might be indicated. It is illustrated in Fig. 13.

Basically, the system consists of a hydraulic torque converter and two epicyclic gear sets in series; it gives three speeds, forward (low, intermediate and high) as well

as reverse. For the low gear the three units operate in series, while for the intermediate gear a multi-disc clutch locks up the front epicyclic gear set so that it rotates as a unit. The drive is then through the torque converter and reduction of the rear epicyclic set only. For high gear a single-plate clutch couples the engine output direct to the gearbox output shaft, thus giving a direct 1 : 1 ratio and by-passing both the torque converter and the gear system. The mechanical reduction through the box is 2·308 on low gear and 1·435 on intermediate gear, while the torque converter has an output/input ratio ranging from slightly over 2 : 1 down to 1 : 1. There is a smooth gradation from a maximum reduction of 4·6 : 1 on low gear to a minimum reduction of 1·435 on intermediate. Reverse is obtained without additional gearing, as the drive is reversed through the front epicyclic set and reduced to a ratio of 2·009 × converter ratio = 4·34 : 1 in the rear epicyclic set.

The change from intermediate to high is made in a single step, but as this step is about the same as that from third to fourth in a conventional four-speed box and very appreciably less than that from second to third in a three-speed box, it imposes no excessive loads on the direct drive clutch. To ensure a perfectly smooth pick-up this clutch is specially "tailored" to suit the characteristics of the particular type of vehicle for which it is required.

The whole mechanism is hydraulically operated, oil pressure being supplied from two gear type pumps, one located at the front end of the gearbox and directly driven by the engine so that it supplies pressure at all times when the engine is running. The second pump is located at the rear of the box and directly driven off the output shaft, thus only supplying pressure when the vehicle is moving in a forward direction. The output from these pumps is controlled by a valve unit which not only acts as a relief valve, but also causes the front pump to discharge freely when the output from the rear pump is sufficient, thus improving the mechanical efficiency of the system. This layout also enables the car to be push started if necessary.

Controls consist of a manually operated selector valve and a governor-operated valve which controls the gear changes.

The selector valve is coupled direct to a finger-tip operated lever placed immediately in front of the steering wheel ; it has five positions indicated by a pointer moving over a quadrant marked P (park), N (neutral), D (drive), L (low), and R (reverse). As a safety precaution the ignition system is so wired that the engine can only be started with the selector lever in the P or N positions. Moreover, in the P position a pawl engages with a notched ring on the output shaft, thereby effectively preventing movement of the vehicle in either direction, even on a steep gradient.

For full availability of engine braking on a long descent, the lever may conveniently be placed in the L position, at any speed below 40 m.p.h. In this position, the transmission will not automatically change out of low gear. It is only in the D position that the governor takes charge and all gear changes, up and down, are made automatically in accordance with the combination of vehicle speed and accelerator pedal position, increase of speed tending to cause a change-up, and reduction of speed tending to cause a change-down.

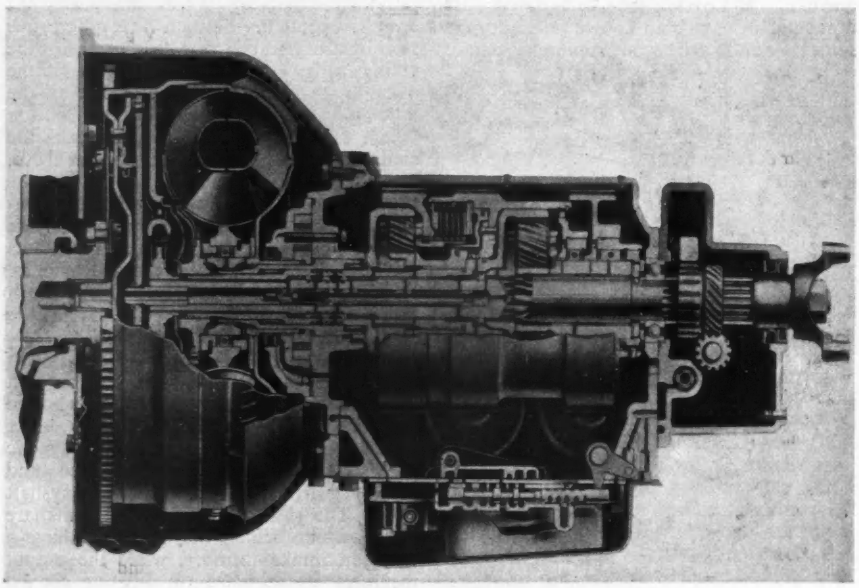


Fig. 13—Borg-Warner automatic transmission

The Rover Company, Ltd., which provided one of the more interesting features of this year's show by exhibiting the prototype of its gas turbine car, can also claim to be the first British manufacturer to fit a vehicle with an automatic transmission of exclusive design. The Rover transmission differs considerably from the known American systems and from the few units designed for use in heavy road and rail vehicles in this country and on the Continent. It comprises a Rover designed and built torque converter and, in addition, some well-tried and readily obtainable components. It is claimed that such a layout not only facilitates production, but also serves the interest of the owners, as the main components—apart from the torque converter which should keep operative for at least 100,000 miles—are sufficiently known to modern garages and repair shops so that service and maintenance could be locally obtained.

The above-mentioned components of the Rover transmission consist of three units, arranged in tandem to form a complete assembly, which, taken in order from the converter housing are : a single dry-plate clutch with vacuum-actuated withdrawal mechanism ; a simple two-speed and reverse synchromesh gearbox with manually-operated gearshift, and an automatic Laycock-de Normaville overdrive. The torque converter, basically similar to the Borg-Warner converter, consists of a pump member attached to the engine flywheel, a turbine runner, connected by a shaft with the clutch disc, and of a reaction member with a freewheel device. The conversion ratio varies from 2·2 : 1 at stalling speed to 1 : 1 at road speeds in excess of about 30 m.p.h. (according to the load), when the converter assumes the part of a fluid coupling. The friction clutch has the purpose of separating the turbine runner from the gearbox in order to facilitate the engagement of the low (indirect) or the reverse gear ratio. The clutch is actuated by a vacuum cylinder, which is controlled by a solenoid-operated valve when energised by a push-button switch on the gear-change lever. The design of the layshaft-type gearbox and of the Laycock overdrive unit follow orthodox practice ; the latter is hydraulically actuated and the change-over from top to over-speed ratio and vice-versa occurs under the influence of a solenoid-operated valve which, in turn, is controlled by a relay circuit in response to a centrifugal governor and to the position of the throttle linkage.

In normal conditions all driving is undertaken in the direct ratio of the gearbox, and the overdrive is in operation only in this ratio. With a final-drive ratio of 4·7 : 1 the maximum transmission ratio in the direct gear equivalent to about 4·7 by 2·2 = 10·3 is sufficient to provide a smooth start and an adequate acceleration up to road speeds in excess of about 30 m.p.h. when the overdrive cuts in, thereby reducing the overall transmission ratio from 4·7 : 1 to 3·6 : 1. The part of the gearbox is to provide an emergency ratio of 8·2 : 1 (neglecting the torque multiplication by the converter) for special conditions, for instance, for restarting on a steep hill or for assisting the braking action of the engine when descending a steep gradient. During normal forward travel, driving is always done in the direct ratio of the gearbox, and all the necessary changes are obtained by the combined action of the torque converter and the overdrive.

While appreciating the reasons which are claimed to have influenced the idea of incorporating in the Rover transmission a number of well-tried components as the automatic clutch, an orthodox gearbox and a proprietary overdrive, it is debatable whether such a layout is indeed less complex and easier to service than other automatic transmission systems. It is difficult, for instance, to see that a unit employing three different circuits—electric, hydraulic and vacuum—should be easier to service than one with a hydraulic system only. The converter of the Rover transmission is called upon to provide, under normal drive conditions, all the necessary torque multiplication from rest up to a road speed of about 30 m.p.h. without the assistance of an additional reduction gear. In order to comply with the present accepted standards of performance and fuel economy, its application will be limited to cars with a favourable power-to-weight ratio.

LOW TEMPERATURE CORROSION CONTROL.—The British Petroleum Company, Ltd., states that from laboratory tests carried out at the company's research station at Sunbury, an inexpensive corrosion inhibition process has been developed whereby ammonia neutralises sulphuric-acid-forming elements in flue gases and so eliminates low temperature corrosion in air heaters and economisers.

138kV Submarine Cable for Vancouver Island

A month ago the Prime Minister of British Columbia, Mr. W. A. C. Bennett, inaugurated the bulk supply of electricity from the mainland to Vancouver Island, via a new power link, the main part of which consists of submarine cable. The contract for the supply and installation of the 91 miles of single-core 138kV cable required for this link was carried out by the British Insulated Callenders Cables group of companies. Gas-filled, pre-impregnated, paper-insulated cable was used because it could readily be manufactured in very long lengtns. Some details of the manufacture and laying of the cable are given here.

THE rapid growth of industry in British Columbia since the war has created some problems in the supply of electrical power. For, while the mainland has plentiful power resources, the neighbouring Vancouver Island is less fortunate. Electricity is supplied to the greater Vancouver area and to the southern half of Vancouver Island by the British Columbia Electric Company, Ltd. When the difficulties of meeting the island's power demands became acute, Mr. Tom Ingledow, who was then chief engineer of the supply company, conceived the idea of making up the power deficiency by establishing a power link from the mainland.

The total length of such a link would be comparatively short (less than 50 miles), but would include a number of sea crossings—the major one, across the Strait of Georgia, being approximately 14 miles across with a maximum depth of 100 fathoms. A preliminary approach was made to the British Insulated Callender's Cables Group in 1952 regarding the feasibility of such a scheme. The problem of long submarine cables was one in which this group had been actively interested for some considerable time, and they were at that time engaged in investigations for the Central Electricity Authority relating to the proposed power cable across the English Channel.

Later, in response to a formal inquiry from the British Columbia Electric Company, the B.I.C.C. group submitted positive proposals for the Vancouver scheme, which resulted, in February, 1954, in the receipt of an order, worth about 3,500,000 dollars, for the supply and installation of some 91 miles of high-voltage single-core submarine cable.

High-voltage power is transmitted at 230kV on the mainland of British Columbia, and at 132kV on Vancouver Island. It was decided that the power to be carried by the cable link, 120MVA, should be transformed from 230kV to 138kV on the mainland for feeding to the link.

Long lengths of submarine cables capable of carrying high power had already been made and laid elsewhere, but these cables had all required large numbers of joints in the conductors, insulation and sheathing, introducing potential sources of weakness into the cables. The most desirable form of cable, therefore, was one that could be made in one continuous length without any joints, but its manufacture raised a number of difficult problems and required much special plant. The solution adopted was to use the single-core gas-filled pre-impregnated paper-insulated cable with which the B.I.C.C. group, of companies has been associated for some years. By using pre-impregnated paper the difficulties inseparable from tank impregnating very long lengths of cable were avoided.

Gas-filled cables for use on land are usually operated at 200 lb per square inch pressure. However, at the maximum depth at which the cable would be laid the external pressure on the cable would be as great as 280 lb per square inch; to prevent an ingress of water in the event of external damage to the sheath the gas pressure decided upon for this cable was 300 lb per square inch. The subjection of parts of the cable to these high pressures made a hard compact form desirable. Thus, instead of following the normal practice in single-core gas cables of having a slight clearance under the lead sheath to facilitate gas flow, the cable was designed to have the sheath a tight fit on the core and to have a central gas duct in the conductor. The use of a duct of purpose-designed dimensions, together with a dielectric of pre-impregnated paper, having little surplus compound, also enabled predetermined uniform gas flow properties to be achieved.

As finally produced, the 0·35 square inch conductor consists of a central spiral steel duct, over which there are two layers of copper wires and a conducting screen of three impregnated metallised paper tapes (Fig. 2). Pre-impregnated paper tapes applied over the metalised paper screen form the dielectric, which is itself screened with copper tape. The lead alloy sheath, extruded to a shrink fit over this core, is reinforced against the internal gas pressure by three layers of tin-coated bronze tape, all applied in the same direction. Between this tape and the jute yarn bedding for the armouring is a protective sheath of vulcanised rubber designed to withstand the highest lead sheath voltages liable to occur in service. The cable is armoured with a single layer of galvanised steel wire, applied in a direction opposite to that of the reinforcing tapes to balance torsional forces. The armour is served with two layers of compounded jute yarn and the cable has an overall diameter of about 4in.

The design of cable adopted would have made it possible to manufacture the cable from stranding to coiling down in one continuous operation. Because of certain disadvantages, however, it was decided to make the cable in three distinct operations: stranding, insulating and lead sheathing, and, finally, reinforcing, armouring and coiling down.

A special manufacturing company, British Insulated Callender's (Submarine Cables), Ltd., was formed, to make cable by the above method for this and other major submarine cable projects. A new cable factory was laid out at Trafford Park, Manchester, adjacent to the Manchester Ship Canal, giving the advantage of deep-water berthing facilities. In-line production was most suitable for the manufacture of long, continuous lengths of cable and it necessitated not

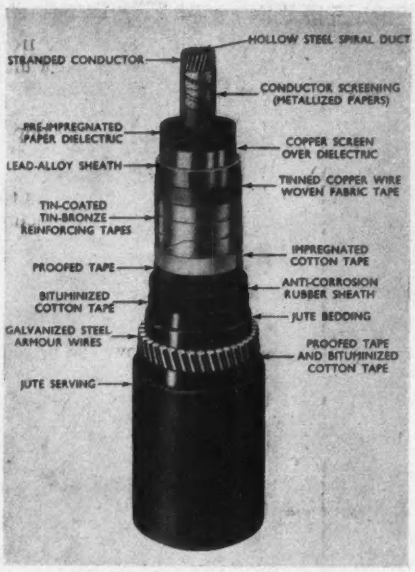


Fig. 2—Stepped sample of 138kV gas pressure submarine power cable for link between British Columbia and Vancouver Island

only many new items of plant, but also the considerable modification of standard plant to adapt it for this specialised method of manufacture.

Among the major items of specially built plant were two large turntables (Fig. 1), to take the lengths of cable after each of the first two operations and then feed it to the succeeding operations, and a length storage mechanism (Fig. 3). This latter item was necessitated by the desirability of having the insulating machine and lead press working in tandem. The pre-impregnated paper tape insulation was applied by a specially designed lapping machine, housed in an enclosure maintained at a constant, low humidity. Special care had been taken in the building, equipping and testing of the lead press to ensure that it was capable of running for periods of up to twenty days without stopping, except for the few minutes necessary for recharging.

A large coiling-down shed, capable of taking the whole of the cable required for this contract, was built between the factory and the Trafford Wharf of Manchester Docks. A gantry, passing over the Trafford Park Road, carried the cable from the factory to the shed and an extension of it carried the cable on to the dockside, directly

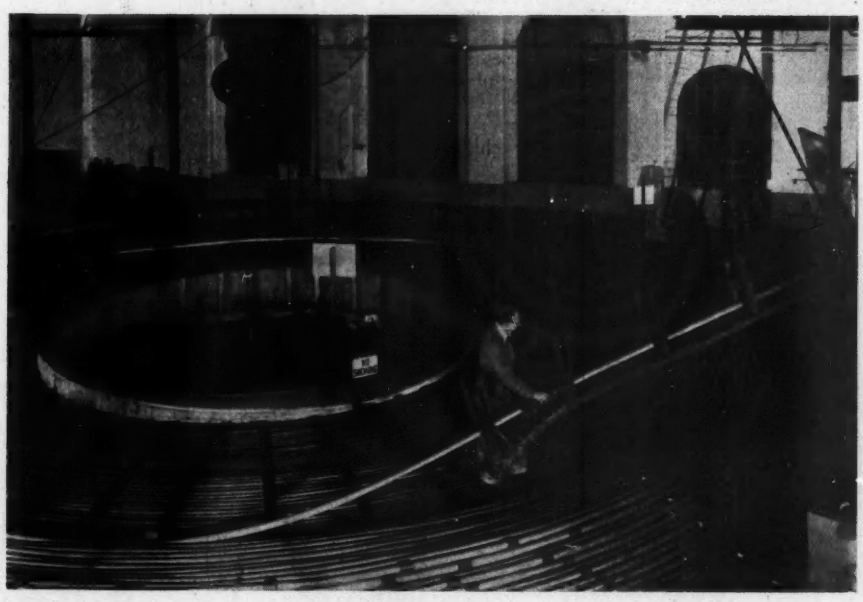


Fig. 1—Coiling down the lead-sheathed submarine cable on to one of the turntables

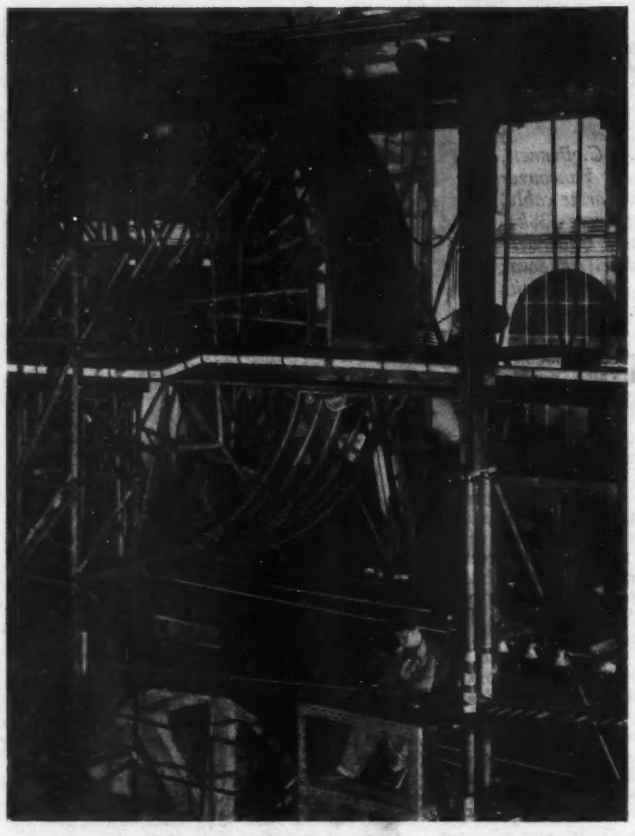


Fig. 3—Part of the length-storage mechanism which enables the insulating machine preceding it, and the lead press following it, to work in tandem

over the tanks of the cable ship, as described in THE ENGINEER, May 11, 1956, page 496.

In this design of submarine power cable the main effort had been to produce continuous lengths of cable that could be laid from shore to shore without joints. However, provision had to be made for repair work and jointing on the cable. A factory joint, suitable for repair of cable damaged during manufacture, was designed and tested. Such a joint was used twice during the manufacture of one of the 16-mile lengths of cable. This length was tested satisfactorily after manufacture and was later put into service without incident.

Joints of special design were developed and after being proved by mechanical and electrical stability and submersion tests a number of these joints were manufactured and delivered to Vancouver before the cable laying operations.

The contract required the cable system to be installed and in operation by the autumn of 1956. During 1954 detailed development work on the cable design and installation of the plant was carried out. Prototype lengths of cable were manufactured and subjected to full-scale proving tests. Manufacture of the first commercial length began in March, 1955. The manufacture of the cable was completed in March, 1956, several weeks ahead of schedule, and the 91 miles of finished cable stored in the coiling-down shed, awaiting transfer to the cable ship. In the original programme two months had been allowed for the cable laying, and the 4600-ton cable ship "Ocean Layer," owned by Submarine Cables, Ltd., was chartered for the job.

Early in May, 1956, loading of cables began at Trafford Wharf. It had been decided that the cables for the short crossing would be laid before those for the longer Georgia Strait (Fig. 4), and the order of manufacture and loading of the cable had been planned to ensure correct maintenance of the ship's trim at all times, combined with correct order of availability of the cables on site. The 3800 tons of cable to be takenwould fully load the ship. In order that the cable tanks should be loaded to their ultimate capacity, the cable was loaded in layers by the "in-and-out" method, rather than the more normal but less compact "layout" method of coiling from the circumference towards the centre adopted on Post Office cable ships.

The scheme finally decided upon by the British Columbia Electric Company was for a.c. power at 60 c/s to be transformed from 230kV to 138kV at Arnott substation in the Delta area of the mainland of British Columbia (Fig. 4) Thence the power would be carried via an overhead route on wooden poles to a point at Tsawwassen Beach, just west of Point Roberts. From there, there would be a submarine cable crossing across the Strait of Georgia to Galiano Island. An overhead line, on steel towers, would then continue the transmission across Galiano Island, an intervening channel and Parker Island. Then there would be a second submarine cable link to a point on Saltspring Island and finally an overhead line across the island and another channel, to Vancouver Island, to be linked, at Stratford substation, with the main Vancouver Island 132kV transmission system. In all, the length of line from Arnott to Stratford would be about 48 miles.

Thus two submarine cable crossings were necessary, the longer one, of about 16 miles, crossing the Strait of Georgia from the mainland near Point Roberts to Galiano Island, and the shorter, of 3 miles, crossing Trincomali Channel from Parker Island to Saltspring Island. The other water crossings incurred were quite short and were to consist of overhead spans of four-conductor lines.

The operating system envisaged at present is a single three-phase 138kV link. In the future the island's power demands may increase sufficiently to require a duplicate link. The ultimate provision of seven single-core cables has been anticipated—that is, two circuits and one spare cable. To provide some spare cables for this initial circuit, the order was placed for the installation of five cables across the Strait of Georgia and four across Trincomali Channel.

A detailed examination of the coastline and a hydrographic survey of the routes between possible landing positions were made for both crossings and, as a result of these, four landing points were selected. Conditions at Galiano, Parker and Saltspring Islands were all similar; steep, tree-lined rocky slopes to the shore, with good deep water offshore. The landing points selected were small, natural coves giving the easiest possible land approaches. At these landing sites concrete chases with provision for seven cables were constructed, from low water mark to near the entrances of the sealing end enclosures (Fig. 5).

From Tsawwassen Beach the ground rises steeply to a height of 180ft. Unfortunately, the cliff, consisting of loose, sandy soil lightly covered with vegetation, was known to be unstable and, when the vegetation had been removed, unsuitable for providing a foundation for a concrete chase as used at the other landing sites. Instead, a concrete surface cable tunnel, 500ft long, was erected down the face of the cliff. The approach to the beach from the water was also more difficult there than at the other sites, as there were mud flats, exposed at low water, for a mile and a half offshore. Beyond that the water increased in depth steadily to a maximum of just over 100 fathoms.

To facilitate subsequent cable identification and, if necessary, recovery for repair, it was planned that the cables should have a spacing of about 500 yards for the main crossing and of about 250 yards for the shorter crossing. Because of the probable future additions, the cable positions were planned on a basis of seven cables per crossing. This wide spacing for so many cables necessitated considerable differences in length between different cables for the same crossing.

To ensure that the cable should lie straight on the sea bed, without appreciable tension, yet without loops, a method of laying was evolved whereby the tension was applied to the cable according to a previously calculated schedule, depending on the depth at the point of laying and based on a nominal laying speed of 3 knots.

For the laying of the shore ends the three landing sites at Galiano, Parker and Saltspring Islands presented no great difficulties, as the ship could approach quite close to the shore and the cable ends could probably have been taken ashore supported on barrels. The shore at Tsawwassen Beach was very different, being similar to that on the French coast from Calais to Cap Gris Nez, and difficulties in landing the shore end were expected. The extremely shallow water so far off shore meant that an alternative to barrelling had to be found. It was decided to coil the cable, about 3000 yards, on to the deck of a scow (a flat-bottomed vessel of very shallow draught), and to lay cable while towing it inshore. When close in, the vessel would be moored and the end pulled ashore. Winches for mooring and for handling the cable and scow, cable brakes, fairleads and other equipments, were designed and produced in the autumn of 1955 and tried out, first on land and then, mounted on a scow, were used, with the "Ocean Layer," in cable laying and recovery trials off Falmouth. This method of landing shore ends proved satisfactory and, since the scows could also be used at the other landing sites, it was decided to use two scows, one for all the starting ends of the cables and the other for all the finishing ends. Two scows were therefore equipped with handling equipment sent out from England earlier this year.

The "Ocean Layer" reached Vancouver City in early July. To enable the team to gain experience on the easier operation, it was decided to lay the shorter cables crossing the Trincomali Channel first, before attempting the longer Strait of Georgia crossing and the more difficult landing at Tsawwassen Beach.

Cable laying was started on July 18th and

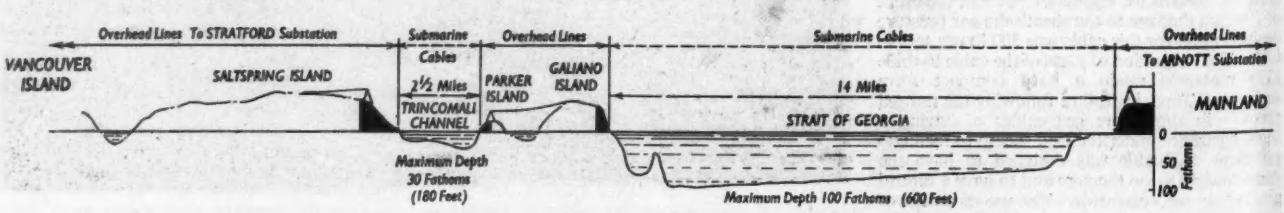


Fig. 4—Diagram of cable route between mainland and Vancouver Island via Galiano Island

Fig. 5—A scow approaching the landing site at Galiano Island. In the background is the cable ship "Ocean Layer"

continued for four weeks in unusually favourable weather. Local tidal conditions had to be allowed for: a double tide could occur, with unusual shore currents; the period of high tide was generally longer than that of low tide during the cable laying; and at times there was no period of slack water.

The laying of the first cables was carried out with day intervals to rest the crews. During the laying of the third short length, as the ship was nearing the buoys off Parker Island, the cable was damaged by excessive pressure on the ship's bow sheave housing. The cable broke down under test and plans were made for repairing the damage after the longer lengths had been laid across the Strait of Georgia.

After laying the fourth short length the cable ship and the two scows moved into Georgia Strait to lay the five 16-mile lengths. Two days had been allocated for laying each cable. Once work had started, it went through smoothly, all five cables being laid within the scheduled ten days. A mile off Galiano Island the sea bed rises rapidly from 100 fathoms to only 40 fathoms, but this caused no difficulty. Work on the shore ends went on simultaneously with the laying.

The cable ship and attendant scows then returned to Trincomali Channel to repair the faulty cable. A 600-yard length of new cable was coiled on to the deck of a scow. The shore end of the cable was then picked up as far as the fault, from a depth of 25 fathoms, and laid on the deck of the scow without difficulty, using its own equipment. The main length of cable was then jointed, on the scow, to the new length of cable, the joint lowered overboard and the new cable end taken ashore. The whole operation took only a little more than two days.

Immediately after each cable had been laid a high-voltage d.c. test was carried out on the cable at atmospheric pressure. The cables were then moved into their final positions in the chases and the ends terminated in sealing ends. They were then gassed and the official high-voltage acceptance test carried out, together with other electrical tests and a pneumatic test to ensure gas tightness. To prevent damage to the cables malleable iron protectors were fitted to the cable at the shore end of the concrete chases to below low-water mark at the three deep-water landings. At the Tsawwassen Beach landing the protectors were fitted for a short distance from the tunnel entrance, the remainder of the shoreward end of the cable being buried in trenches.

All the cables were made alive in turn after the first trial transmission of power to Vancouver Island had taken place in late August.

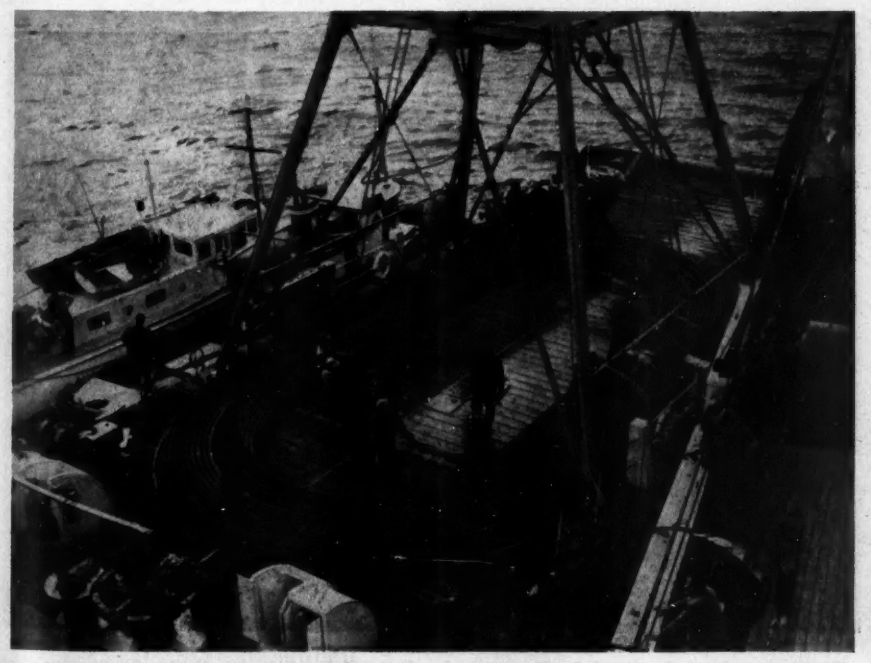
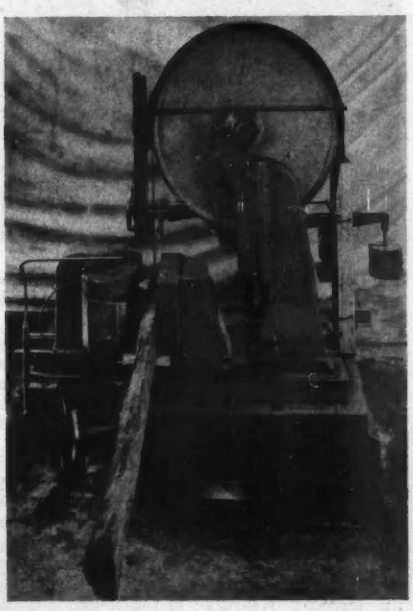


Fig. 6—Cable for landing on Tsawwassen Beach being loaded on to the deck of a scow from the cable ship

Band Resaw With Hydraulically Operated Feed

A NEW design of band resaw machine specially intended to deal with wet timber and rough slabs which is now being made by Stenners of Tiverton, Ltd., Lowman Works, Tiverton, Devon, is fitted with hydraulically operated feed gear. This machine, known as the "V.H.S.48," has a sawing assembly generally similar to the firm's "V.H.K.48" resaw with 48in pulleys taking a 5½in wide saw. It can also be supplied with heavier sawing assemblies for 6in, 7in or 9in wide saws.

The general design of the machine can be seen in the illustration below. Its serrated feed rolls and the four fluted rolls in the fence are driven by hydraulic motors. Hydraulic rams are fitted to open the feed rolls up to 12in from the saw line and to adjust the fence up to 9½in from the saw line. With this form of drive a stepless range of feed speeds are available from 20ft to 200ft per minute.



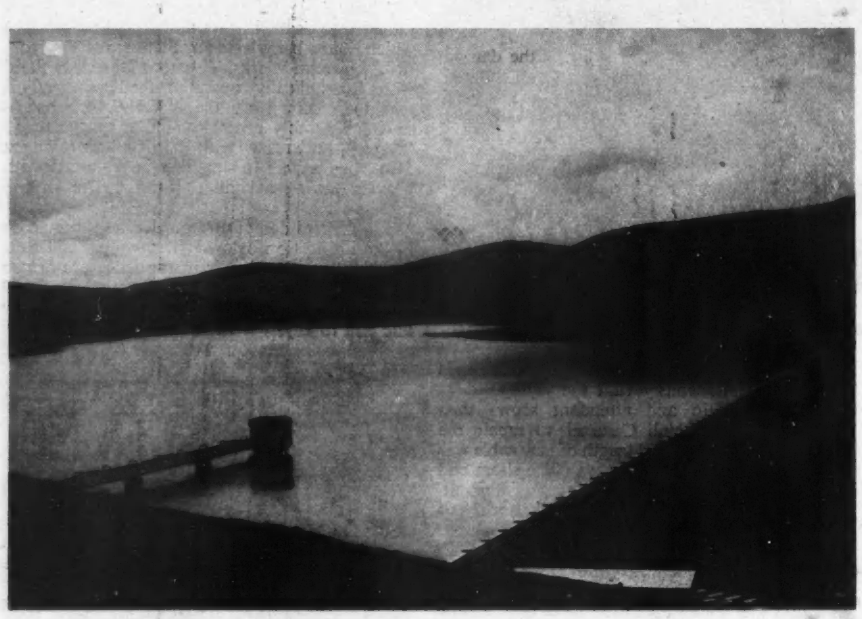
In-feed side of 48in band resaw with hydraulically operated feed rolls and fence adjustment

A guard plate on the feed roll assembly is connected to the hydraulic system of the opening ram in such a way that when the plate is contacted by a log the rolls are opened just far enough to admit the log. When a large log follows a smaller one into the machine the feed rolls are thus automatically adjusted to take the thicker section. This automatic adjustment provides a safety measure in that should an operator's clothing or arm be caught by the feed rolls the pressure of his body against the guard plate automatically opens the rolls for him to draw clear.

The fence has twenty-four preset positions up to its 9½in maximum opening and these positions are quickly selected by depression of a pedal or by turning a large adjustment wheel. Intermediate dimensions for cutting purposes are obtained by the introduction of gauge slips. The maker points out that the machine can also be used as a conventional resaw if required.

Inauguration of the Daer Water Supply in Lanarkshire

THE Daer water supply scheme in Lanarkshire was inaugurated by Her Majesty the Queen on Tuesday, October 16th. The scheme is a large one which is capable of supplying 28·35 m.g.d., and is of interest because it has been initiated by a regional body, the Daer Water Board, to supply water to a number of local authorities, each of which had previously developed its own, more local, sources of supply. The principal statistics relating to the scheme are listed in the table, which also enumerates the constituent water authorities, referred to above, of the Daer Water Board, and shows how the initial yield is divided amongst them.



The Daer earth-fill dam and reservoir in Lanarkshire. The valve tower and access bridge are shown to the left, and part of the spillway structure can be discerned on the downstream side of the dam

The main engineering work of the scheme is the large earthen embankment which impounds the reservoir. It has a maximum height of 135ft, and is believed to be the largest earth-fill dam yet constructed in this country, its cubic content being 2,300,000 cubic yards. The Daer is one of the two headstreams of the River Clyde, and the reservoir is situated in the southern tip of Lanarkshire. A treatment works has been built close to the dam, and a pipeline leads from it over a distance of about 56 miles to the terminal reservoirs; the latter have been built by the constituent authorities, where the supply enters their various systems. The entire scheme, excluding these terminal reservoirs, has cost about £5,750,000, direct constructional costs accounting for all but about £500,000 of this total. Work has been in progress since 1948.

The dam is shown in the accompanying cross-section, and in the photograph reproduced above. Its design and construction have generally followed established practice for such structures. The filling material was placed in layers which were mechanically compacted, and watertightness is achieved with a reinforced concrete core wall, with a cut-off below it. The cut-off trench was excavated to a maximum depth of 35ft through drift clay into rock, and the customary pressure grouting was carried out from the trench bottom. The core wall or diaphragm is articulated; its thickness is 3ft 6in at the top of the dam, and 6ft 9in at the deepest part. The upstream face of the dam is protected by concrete slabs which extend up to a wave wall, 5ft high, at the crest; the downstream face has been soiled and sown with grass seed.

Filling material for the dam was excavated from borrow pits within the final limits of the reservoir. A difficulty was caused here by the prevalence of peat, which had to be removed before any material could be won. Altogether, about 500,000 cubic yards of peat had to be removed to a tipping area downstream from the dam. With the heavy "Euclid" trucks which were in use on the site, the peat tip presented a difficult problem, since the tipped material was too soft to be travelled over. A solution to this problem was obtained by building a bridge over a narrow gulley, and leaving a hole in the bridge, through which the trucks could discharge their loads of peat. The peat gradually flowed away, as more weight was added to the tip, thus keeping the way clear for continual tipping.

During construction the Daer stream was diverted through a culvert 9ft 6in in diameter. The culvert was plugged, when impounding was due to start. Water control at the dam includes a 36in scour pipe and a 42in stand pipe in the valve tower, with intakes at levels of 27ft, 57ft and 87ft, respectively, below top water level, each of which is controlled by an external sluice and an internal valve. The valve tower and its approaches are independent of the embankment, as the illustration shows. The supply passes from the intake tower to the treatment works through a 42in pipe, laid partly in the diversion culvert. There is also a spillweir 220ft long, built along the right bank of the reservoir at the end of the dam; it leads to a stepped channel, terminating in a stilling pool. Compensation water is discharged through two 60kW turbo-alternator sets installed in a turbine house at the downstream end of the diversion culvert. The tail-race leads into the stilling pool, and thence to the river bed, where a compound venturi flume has been built for flow measurement.

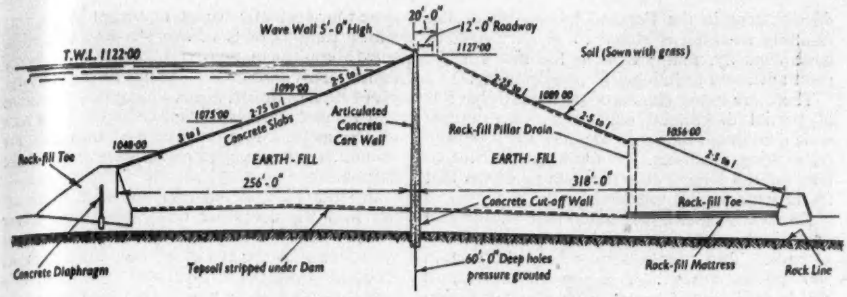
Principal Statistics for the Daer Water Supply

Yield:	
Yield of reservoir for supply	28·35 m.g.d.
Compensation water	5·53 m.g.d.
Present yield of first stage pipeline	14 m.g.d.
Reservoir:	
Catchment area	11,700 acres
Average annual rainfall	75·9in
Reservoir capacity	5,600 m.g.
Top water level	1,122ft A.O.D.
Corresponding reservoir area	500 acres
Embankment:	
Maximum height	135ft
Length	2,600ft
Width at top	20ft
Maximum width at base	680ft
Volume of filling material	2,300,000 cubic yards
Treatment works:	
Ultimate capacity	31·2 m.g.d.
Present capacity	15·4 m.g.d.
Pipeline:	
Approximate total length	56 miles
1st section: treatment works to Douglas Moor break pressure tank	17 miles, 44in diameter
2nd section: break pressure tank to bifurcation point	13·6 miles, 33in diameter
3rd section: westerly leg	11·8 miles, 21in diameter
northerly leg	14 miles, 22in and 26in diameter
Division of 1st stage supply:	
Lanark County Council	8·2 m.g.d.
Airdrie, Coatbridge and District Water Board	2·5 m.g.d.
Town Council of Hamilton	1·4 m.g.d.
Town Council of Motherwell and Wishaw	1·9 m.g.d.
	14·0

Water Treatment and Pipeline

The treatment works at the dam site can be seen in the accompanying illustration. The flow of raw water is measured at a venturi flume, and sulphate of alumina is added, to form a "floc"

Treatment works at the site of the Daer reservoir. Sedimentation tanks are shown with the filter-house behind them



Typical cross section of the Daer earth-fill dam

which removes the colour and fine particles present due to peat. The water then passes through sedimentation tanks and rapid gravity filters. Finally, a small dose of lime is added to neutralise any acidity due to peat, and chlorine is added. Power for operation of the treatment plant is normally provided by the compensation-water generating sets, but a stand-by diesel set is also installed.

The trunk pipeline of the scheme has steel and cast iron pipes, lined and sheathed with bitumen, and jointed with flexible couplings. Sluice valves are installed at about 5-mile intervals and the diameter of the pipeline varies as bulk supplies are taken at various points along the route. There are several river crossings, including a double-span pipe bridge over the River Clyde, where the highest static head of the system—that is about 950ft—is encountered.

The entire Daer scheme has been designed by the consulting engineers, Messrs. Binnie, Deacon and Gourley. The main works at the dam site have been built by direct labour, under the consultants' supervision. Only the pipelines and various items of special plant were let out to contract, the principal contractors being as follows: treatment works equipment, United Filters and Engineering, Ltd.; compensation-water generating sets, Gilbert Gilkes and Gordon, Ltd.; pipe-laying 44in pipes, Hugh Leggat, Ltd., 33in, Crowley Russell and Co., Ltd., 26in to 21in, Andrew McCracken and Co., Ltd.; supply of steel pipes, Stewarts and Lloyds, Ltd., cast iron pipes, The Stanton Ironworks Company, Ltd., valves, Glenfield and Kennedy, Ltd. A paper on the scheme, by Messrs. Kerr and Lockett, is to be presented at the Institution of Civil Engineers on January 15th.

Factory for Electronic Digital Computers

ON October 1st, the Press was invited to visit the new Ferranti factory at West Gorton, Manchester, 12. The factory, parts of which are still being converted, was formerly producing textile machinery. It is now being used for the series production of "Pegasus" and "Mercury" electronic digital computers.

Our illustration, Fig. 1, shows the batch assembly of "Pegasus" machines. These units are connected to their special power supply, the cables for which are laid in channels in the floor from the motor-converter sets (one of which can be seen on the left) and cabinet mounted mains units. We have previously given a brief description of the "Pegasus" (see THE ENGINEER, July 15, 1955, page 88). With the "Pegasus" computer, which is manufactured under licence from the National Research Development Corporation, the maker claims that a fast and powerful machine has been produced at moderate cost. Following the introduction by Ferranti in 1951 of the first commercially available electronic digital computer—the "Manchester" model—the methods of applying these machines to work of industrial interest have been intensively studied. It is as an outcome of this experience, and the rapid technical developments of recent years, that the main lines of the present design have been determined.

Ease of programming having been a foremost consideration in the design, "Pegasus" has a comprehensive range of "orders," which define the operations that the machine is able to carry out on the numbers within it. All functions likely to be in frequent use are provided and the order of operations of the machine correspond as nearly as possible to those which seem natural or obvious to the programmer. The ease of programming makes it simple to introduce minor changes in a programme to meet some change in the requirements.

A comprehensive range of programmes and sub-routines is available with the machine to assist the user in preparing his work. Complete programmes have been written for calculations which are of widespread interest, e.g. the stress analysis of aircraft wings, wage accounting, readership surveys and many more.

Sub-routines, e.g. for finding roots, sines, logarithms, for converting £ s. d. to pence, can be incorporated in a master programme. These sub-routines are collected on a library tape, which is distributed to purchasers. A tape reader can be made to scan the library tape and select the sub-routines required. "Pegasus" has a high-speed computing store and a slower large-capacity main store. The actual computations are carried out in a group of immediate-access stores of nickel delay-lines, each holding one "word," i.e. either a number or a pair of orders.

Seven of these registers ("accumulators") besides doing normal arithmetic, can be used to modify the addresses of orders and can count the number of times complete repetitive processes are carried out. These multiple accumulators greatly simplify the writing of programmes. The major part of the computing store is made up of forty-eight registers. Other special registers are provided for the input and output of information and for certain simple constants.

The main store is a magnetic drum containing 5120 "words," and revolving at 3720 r.p.m. Information stored on the drum, both orders and data, up to 4096 "words," is transferred automatically to or from the computing store in blocks of eight words or single words as required for the computation. The maximum access time is one revolution, 16 milliseconds, and so the average access time is 8 milliseconds. Since transfers are usually in blocks of eight words and there is immediate access within the computing store, the effective access time to the main store is often only 1 millisecond. Particular attention has been given to simplifying the transfer of information between the computing and main stores so that for many problems (e.g. matrix work or sorting) the programmer has the use of one large fast store.

Written permanently on an isolated part of the drum are the input programme, which enables the machine to recognise and accept information from the outside world, and checking and test programmes for the programmer and engineer. These storage locations (1024 "words") may be read from but not written into.

Of great importance are the self-checking facilities of "Pegasus." Some of these are built into the machine. Each register in the computing store and every storage location in the main store has a check digit associated with it. Whenever a register or storage location is used this check will detect whether a binary digit has been erroneously lost or gained, and the computer is stopped. There are also facilities to detect whether the contents of any register have overflowed, or become too large at some intermediate stage in the calculation. The machine will always stop if asked to do something nonsensical.

Other checks are associated with the technique of using the machine, and are brought into operation as instructions or data are taken into the computer, thus picking up any faults which have slipped past the person preparing the work.

Monitoring facilities are provided making it possible to examine any register in the computing store and to stop on any specified order. Orders can also be obeyed one by one under hand switch

Fig. 1—Assembly of "Pegasus" electronic digital computers at West Gorton

control, an advantage when testing for one's own mistakes in trial runs of the programme.

The Ferranti "Pegasus" computer has a "word" length of thirty-nine binary digits; a number consists of thirty-eight digits and a sign digit (equivalent to eleven decimal digits). Two orders are stored within one word length. The digit time is 3 microseconds. Most orders take 0·3 millisecond to be carried out. Multiplication takes 2 milliseconds, division 5·5 milliseconds.

Orders and data are fed into the machine on punched paper tape, which is read in by Ferranti high-speed photo-electric tape readers at a rate of up to 200 characters per second, each character consisting of an arrangement of up to five holes in the tape which represents a number, a letter or a symbol. Two tape readers are used, switching between them being arranged by the programme. Results are presented by a tape punch working at thirty-three characters per second. This punched paper tape is then typed out by a teleprinter at seven characters per second. A tape spooler can be used for both feeding and winding tape.

Provision is made for the later addition of other input/output devices e.g. punched cards or a high-speed line-at-a-time printer, working via auxiliary magnetic tape equipment. A high-speed switching system permits any one of a number of input and output devices to be automatically selected; this is of particular value for certain data-processing or automatic control applications.

Ease of maintenance is achieved by the electrical layout which is in the form of a number of plug-in packages. A faulty package in the computer will be detected by the test programmes or by the automatic checking facilities. It can then be quickly replaced by a spare. As a marginal testing facility the high-tension voltages may be varied while the machine is running. In this way a faulty component is detected before it fails in normal use. Its position is located with the help of test programmes.

Any suspected package may be tested on a special package tester. The various tests are selected by switches and the indications given on the meter or cathode-ray tube monitor are compared with those stipulated in the maintenance manual. Thus any faulty component may be tracked down and replaced. When the package has passed its tests, it is returned to the stock of spares for the computer. Power requirements are 12kVA supplied through a motor alternator from an a.c. supply.

The second machine being built at West Gorton is the "Mercury" computer (Fig. 2). In the design of this large-scale electronic digital computer, the aim has been to produce a machine which will be principally used in performing calculations of a scientific and technical nature. The design has been evolved with the collaboration of Manchester University; the engineering techniques have resulted from research and development in the Ferranti laboratories. The resulting machine is stated to be very fast, of large capacity, and providing facilities for the most advanced techniques of programming.

There are many classes of problem (large sets of partial differential equations, for example) which, although they may theoretically be solved on existing machines, are found in practice to take far too long. It is for such problems that the new machine is intended.

As regards speed, it is stated that arithmetical operations take on average only 180 microseconds. Two numbers may be multiplied in 300 microseconds. A group of operations chiefly used for the organisation of a calculation takes only 60 microseconds. An important factor contributing to the high speed of operation is that there is no delay associated with obtaining any number held in the computing store. At this speed, it becomes possible to perform calculations of a nature hitherto considered intractable.

Even more important, it is stated, is the fact that all arithmetical operations are carried out on numbers represented in floating-point form. This means that numbers are stored in two parts: a standardised fractional part (in the range one-half to one, positive or negative), and an "exponent" part with a sufficiently wide range to accommodate all numbers likely to occur in practical computations. This arrangement ensures that all numbers are held and handled within the machine in such a way that overflow of any register cannot occur. The range of the numbers which can be accommodated is, in practice, unlimited; in scientific problems this is a great advantage, as it is generally difficult to predict the ranges of the variables of the computation without doing subsidiary calculations.

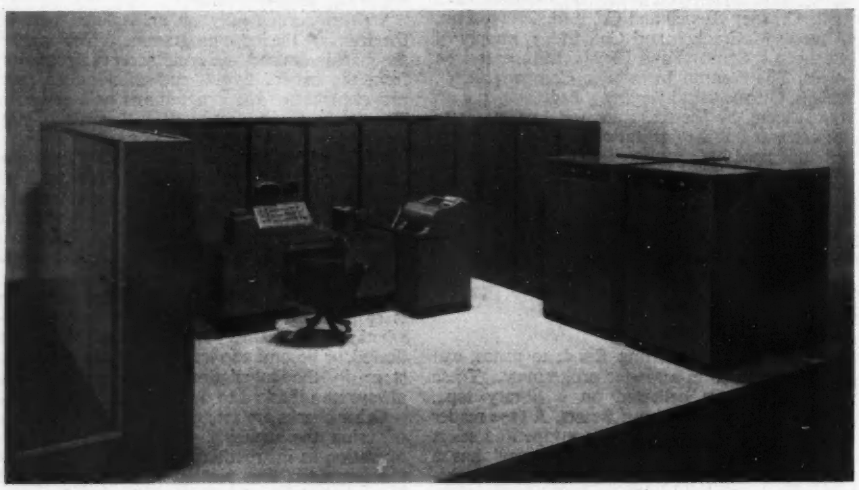


Fig. 2—The "Mercury" electronic digital computer

The third main aspect is storage capacity. Like the "Pegasus" model, the computer has a high-speed store in which all the computation is done, backed by large-capacity magnetic drum storage units. In "Mercury" the computing store is sufficient to hold large sections of a calculation.

It consists of magnetic cores, a form of storage which will ensure long periods of trouble-free operation, and has the very large capacity of 1024 ten-digit words (a word being one number or two orders). This capacity may be reduced to a half or a quarter for special or restricted applications. The ferrite cores are arranged in square arrays of size 32 by 32, and forty-four such arrays comprise the whole computing store. The ten digits of any short word, and the associated check digit, are stored in the corresponding positions of a group of eleven squares. Any core is interrogated by energising the appropriate horizontal and vertical wires, and reading the answer on a diagonal wire. The ten digits of a short word are available to the arithmetical unit in parallel, and are converted into serial form for all operations within the computer.

The "Mercury" computer has for its backing store four magnetic drums rotating at 3472 r.p.m., with a total capacity of over 4×4096 forty-digit words, equivalent to over half a million binary digits. This storage is sufficient for a very large proportion of the problems which occur in science and technology, and obviates the need for such devices as punching out intermediate results for re-input to the computer at a later stage of the calculation.

Programme material and numerical data are fed into the computer on five-hole teleprinter tape, which is read by a Ferranti high-speed photo-electric tape reader at 400 characters per second. Results are presented by means of a medium-speed tape punch, working at thirty-three characters per second, on a tape which may be printed out by means of a teleprinter. Provision is made for the addition of other input/output devices (e.g. magnetic tape) if these are desired. The teleprinter code for both input and output has been chosen in such a way as to make it extremely unlikely that any errors which might occur shall pass undetected.

Along with every group of digits inside the machine is stored an extra digit which is used for checking purposes only. If a defect in the computing store should cause any number to change, this would automatically be detected when the number was next referred to. There is a similar check on the information in the backing store.

The instructions for the Ferranti "Mercury" computer are obeyed in the same order as they are written (unless a specific break is called for), and the full computing speed is obtained without having to consider any special arrangement of the instructions, or the timing of one relative to another. Thus, the difficulties of "optimum programming" do not arise. Decimal numbers are used to define the functions, and the addresses of the storage locations. There is a single accumulator, and each instruction refers implicitly to this accumulator, and to one other number, referred to through its address in the computing store. For example, "add the number stored in address 30 into the accumulator."

A very full range of approximately sixty functions has been provided, and their codes have been arranged in a logical manner for the benefit of the programmer. As in previous Ferranti computers, in order to facilitate repeated operations on a series of numbers (i.e. where similar operations are carried out on numbers in a series of addresses), special registers have been provided, which are known as B-registers. Every instruction specifies one B-register, of which there are seven, and the effect is that the contents of this B-register are added to the address part of the instruction before the instruction is obeyed. One of the B-registers may be used as a short accumulator when it is desired to work with small integers equivalent to about three decimal digits.

Instructions involving the B-registers require only 60 microseconds for their execution. This implies a reduction in the ratio of the time spent in carrying out "red-tape" instructions (i.e. those instructions required solely for the organisation of the calculation), to the useful computing time.

Dielectric Irradiation Laboratory

For investigating the special properties of irradiated dielectric materials, the research organisation of British Insulated Callender's Cables, Ltd., has for several months been operating a 2,000,000V Van de Graaff accelerator at its Wood Lane laboratories. This equipment was chosen for the work because of its flexibility, in that it can act variously as a source of electrons, positive ions, gamma-rays and neutrons. In particular, however, the high energy radiation thus produced is being used to modify the structure and properties of conventional polythenes. A comprehensive programme of study of the physical and electrical properties of such materials after irradiation, has been started, with special emphasis on their uses as cable insulants.

The irradiation laboratory comprises a central generator block of two storeys, with the target room on the ground floor immediately under the generator room, flanked on each side by cable handling and control laboratories. The concrete walls of the target room are 3ft thick to prevent

Experimental transmitting equipment for radio-propagation by tropospheric scatter. The 30ft diameter radiator is energised by a feed horn in the transmitter trailer, which is on a circular rail track

the radiation in the laboratories from rising above the tolerance level, while those of the generator room in which the radiation intensity is lower, are 2ft thick.

Cable under radiation traverses the target room through two slits in the concrete walls, and is handled by conventional take-up and haul-off cable machinery. The leakage of dangerous amounts of X-radiation and of electrons into the laboratories is prevented by covering the slits on the outside with 6in thick lead bricks and on the inside with rubber snuggers and aluminium doors.

The electron beam from the accelerator tube in the generator is scanned electromagnetically so that it emerges from the aluminium window of the scanning bucket as a beam having its longer axis parallel to that of the cable.

With these arrangements it has been found possible to process continuously polythene-insulated cables. First investigations into the properties of such cables, after irradiation, have indicated that amongst other advantages, a substantially raised softening temperature results. The irradiation plant is the first in Great Britain to process plastics-insulated cables in this way, and will help in the assessment of irradiated materials for general use in the cable industry.

British Research into Radio Propagation by Tropospheric Scatter

IN Great Britain, as in other countries, research is being carried out into the possibilities of radio propagation by tropospheric scatter.* The principle of this system of propagation is that radio waves are directed into the upper atmosphere (troposphere), where scattering occurs, part of the energy being deflected forward and downward and reaching the earth again at a point remote from the transmitter. Scatter also takes place in the ionosphere, but only at frequencies below about 60 Mc/s, whereas tropospheric scatter, as a possible means of radio communication, promises to be useful at frequencies up to 10,000 Mc/s. Experimental equipment using the principles of tropospheric scatter has already yielded transmissions over distances many times greater than the "line of sight" limit which characterises ultra-high-frequency equipment now in general use.

We have recently received a brief outline of the work done on tropospheric scatter by Marconi's Wireless Telegraph Company, Ltd. After propagation tests extending over several years, this company has now brought into operation a tropospheric scatter link between Great Bromley, Essex, and Sutton Bank, near Thirsk, Yorkshire, the distance involved being about 200 miles. Field strengths are recorded continuously over this link; various kinds of modulation are available, so that studies can be made of multi-path effects, the effect of aircraft and other relevant problems. Preliminary tests have already been made over a 400-mile circuit to Aberdeen, and it is hoped later to establish a link over this distance.

Plans are now in hand to set up high-power (10kW) transmitters and associated receivers at Newcastle upon Tyne, and in the London area, with the object of being able to operate up to thirty-six simultaneous telephone channels or a television link between these points. The equipment is being designed and constructed by Marconi's as a private venture and the link is intended to be used for tests and demonstration only.

The present transmitter, sited at Great Bromley, is housed in a Services type trailer, illustrated above. Operating on a frequency of 858 Mc/s, the transmitter has an output of 500W and is capable of being frequency-modulated by a multi-channel signal or amplitude-modulated by a television waveform, or by pulses. The actual radiator consists of a 30ft diameter dish, the lower edge of which is mounted about 30ft above ground level; this radiator is energised by a feed horn mounted on the transmitter trailer. The radio beam can be steered in the horizontal plane by positioning the transmitter trailer on an arc of railway track which is laid in front of the radiating dish. Adjustment of the beam in the vertical plane is also possible, since the feed horn is mounted on a small boom, which can be raised or lowered as necessary. The receiver is contained in a mobile laboratory. To obtain the maximum mobility the receiving aerial, which is mounted on a trailer, is only 10ft in diameter.

The link has now been in continuous operation for six months. Results from this and the original research are such as to indicate a sound commercial future for communication systems making use of the tropospheric scatter principle. In the course of the experimental work done by Marconi's, theoretical predictions have been generally confirmed, while a number of interesting phenomena not previously anticipated have come to light.

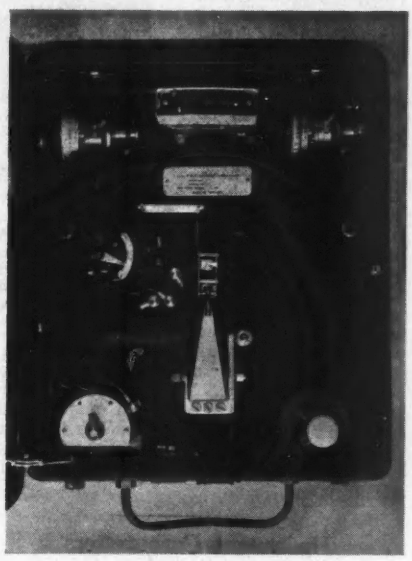
For the future, the ultimate limits of transmission will depend largely on the transmitter power available. With a power of 100kW it might be possible to achieve telegraph transmission out to distances of the order of 700 miles. The ultimate operational limits are not yet established, but it would seem that there is a possibility of an eventual transatlantic television service by the tropospheric scatter system. This, however, would have to be carried out in a series of "hops" as the maximum range for reliable television transmission by any one link is only about 250 miles. A much nearer possibility is a direct European television link—for example, from Holland to Britain.

* American work on this subject was described in an article, "Forward Scatter of Wireless Waves," in our issue of August 10, 1956, pages 210–213.

Slack-Diaphragm Pressure Controllers

A NEW series of seven slack-diaphragm-operated pressure controllers is now being made by George Kent, Ltd., Luton. These controllers are all of non-indicating, non-recording, blind-setting design, and comprise suction or pressure controllers. They include a special-purpose furnace-pressure controller, differential-pressure controllers, a special-purpose instrument for the automatic load control of suction or pressure pulveriser mills, and an air-flow controller or differential-pressure transmitter. The general appearance of all the instruments in the "FAF" group, as it is known, is similar, and one is shown in the accompanying illustration. The instruments have an 18in by 15in door, and all are suitable for wall, panel or post mounting.

An edgewise gauge at the upper centre of the door shows the "supply" and "control" air pressures of the firm's Mark 20 controlling circuit, expressed as percentages between minimum and maximum range, and any one of a number of mechanisms in the Mark 20 series



Slack-diaphragm suction or pressure controller for for values up to 6in w.g.

of pneumatic controlling units can be fitted in the instruments. This equipment can be supplied on arrangements to cover the following control terms and facilities:—Proportional only (0 to 60 per cent proportional band); proportional (0 to 60 per cent) plus derivative action; proportional (0 to 650 per cent) plus integral action, and proportional (0 to 650 per cent) plus integral plus derivative action; the controlling units with the 0 to 60 per cent proportional band are fitted only where it is known that the band could in practice be 5 per cent or less, because the instruments are substantially of the force-balance type. The output signal of the Mark 20 controlling unit varies between 3 lb and 15 lb per square inch. Controlling units employing integral and/or derivative action are provided with control action adjusting knobs scaled in time increments between 0·15 and 40 minutes' action time.

In the instrument case there are incorporated an air-reducing valve, a relay, and an auto/manual switch. Where special testing and servicing

facilities are required for controlling, the instrument is associated with the Kent auto/manual/test/service and remote manual station. Where "overshoot" of the desired pressure value, following a period of regulator saturation, is likely to cause difficulty, and where integral action is used in the controlling unit, the firm can supply its automatic bleed and/or automatic injector devices for insertion in the control circuit, connected up as an integral-pressure desaturator within the instrument case.

All the instruments are designed to operate with the diaphragms in the mid-position, corresponding to a 9 lb per square inch output of the 3 lb to 15 lb per square inch controlling unit. The desired value setting of all the controllers is easily adjusted, and the only maintenance required is the occasional removal of condensation from the filter sump of the controlling unit.

Small Welding Positioner

A WELDING positioner of simple construction manufactured by Courtburn Positioners, Ltd., of Bedford, which is illustrated below, can be used for general welding work or assembly of small components. It has a circular top plate, which can be rotated through 360 deg. and locked by a hand nut in any desired position. A 9in diameter top plate is fitted as a standard, but larger sizes can be supplied, if required. This plate is fixed on a segment mounting through which it can be tilted from horizontal to vertical in either direction, and then locked by a steel peg locating in any of a series of drilled holes.

Welding positioner of simple construction with a rotating work plate which is adjustable for angle and height

The top plate assembly is mounted on a tubular column, which can be raised in the stand pillar and secured to provide any working height from 2ft 10in to 4ft above floor level. A tool tray is provided on the column for the convenience of the operator.

For fitting and assembly work as well as for some welding operations the positioner can be supplied with a D-shaped top plate slotted to accommodate a turret jaw vice. This vice has a rotating rear jaw shaped to hold round, angular and awkward shaped work. Horizontal and vertical vees are provided for gripping bars and tubes, and tapered objects can be gripped in the self-aligning jaws.

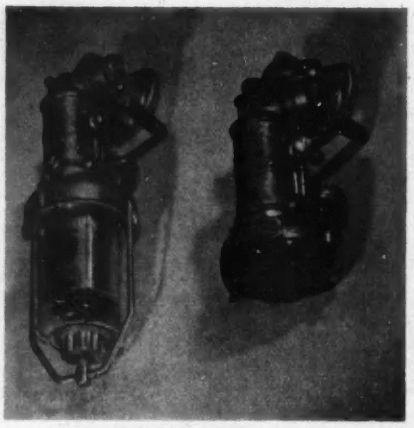
Updraught Carburetters

A CARBURETTER incorporating an air cleaner has been evolved by the Villiers Engineering Company, Ltd., Marston Road, Wolverhampton, and is being used on the Marks 10 and 12 four-stroke engines of 98 c.c. and 120 c.c. capacity. The air cleaner may be either oil-wetted or oil bath, the respective adaptors being attached to otherwise identical carburetters.

The oil-wetted unit consists of a galvanised knitted wire mesh in an openwork plastic moulding secured by two spring clips; servicing consists of washing in petrol and immersing in thin oil.

The oil bath unit, intended for use in heavily dust-laden atmospheres, has a transparent plastic bowl, so that there is no difficulty in maintaining the correct oil level. Both the bowl and the cartridge type filter element can be serviced in a few minutes. The carburetter being updraught, a ledge is provided to catch petrol running out of the throat in the event of flooding and divert it to a porous sintered bronze drain plug.

The main body of the carburetter comprises two castings, the upper being common to all engines and the lower incorporating the choke tube and available in various sizes. The needle valve and the main jet are screwed in from outside the body and easily replaceable. The pilot jet is in the upper face of the float chamber casting; a screw adjustment for its mixture is provided. This lower part of the body is retained by two screws, and includes a spring-loaded strangler.



Villiers "B.10" carburetters, the model on the left being fitted with an oil bath filter and that on the right with an oil-wetted gauze filter

Carburetters intended for vaporising oil are provided with an outlet hole for drainage purposes below the bottom of the float chamber, control being by a drain screw.

Mechanical Harvesting of Sugar Beet

SINCE 1946, the British Sugar Corporation has organised annually a working demonstration of sugar beet harvesting machines. Each year a different beet growing area of the country is visited, with the result that designers, manufacturers and users of these harvesters are able to see them in operation under varying conditions. This year's demonstration was held last week at Abingdon, Berkshire, where, for two days, twenty-three machines were worked in a fairly heavy beet crop. The majority of the machines were "complete" harvesters; that is, they performed, in sequence, the operations of topping, lifting and depositing the beets either in windrows or into a truck running alongside.

The general principles of the construction and operation of sugar beet harvesters have already been described in these columns, and none of the machines which we saw last week differed radically from those which have taken part in the demonstrations during the last three or four years. A spring-loaded topping knife followed by lifting shares which virtually squeeze the beets from the ground seem now to be generally accepted for mechanical beet harvester design. The demonstration at Abingdon last week emphasised that greater efficiency is now being achieved in the succeeding operations of cleaning and depositing the harvested crop. Machine designers and manufacturers are obviously continuing to make careful study of this matter, and progress in beet harvesters is noticeable in the cleaning riddles and conveying arrangements. But, as was pointed out more than once at the demonstration, "there is still some way to go for more attention must be given to the cleaning of the roots."

A report on mechanical beet harvesting in 1954 and 1955, prepared by Mr. Oswald Rose, of the British Sugar Corporation, stresses the same point by saying: "how to combine maximum cleaning with minimum root damage is a point that still needs great attention." The general indications are that, both from the financial and labour standpoints, direct loading will emerge as the most economic method of harvesting, so that cleaning at the clamp by the use of improved kinds of elevator may well figure prominently in future developments. Mr. Rose adds that "in this connection it is interesting to note that, in Sweden and Germany, where mechanised beet harvesting is now making considerable progress, nearly all machines are drawn by tractors which operate outside the crop, thus avoiding the consolidation of soil around the roots which inevitably occurs when tractor wheels have passed between the roots."

The actual acreage of sugar beet grown in this country varies little from year to year; it exceeds 400,000 acres, and this year it is estimated that the yield will be about 5,000,000 tons of beet, which will be processed in the eighteen factories operated by the British Sugar Corporation. When the annual harvesting machinery demonstrations started in 1946, less than 1 per cent of the total acreage was dealt with by the 118 harvesters which were operated. Last year, 42·8 per cent of the total crop was mechanically harvested by the 4400 machines which were at work throughout the country. It should be added that in one area last year, that of the Spalding factory, 65 per cent of the crop was mechanically harvested, the yield averaging 15·1 tons an acre. This year, in the harvest which is now in full swing, it is expected that 50 per cent of the sugar beet crop will be gathered by machine.

The sugar beet harvest, or "campaign" as it is generally called, lasts normally for about four months, from October to February. Last year, the 4,555,938 tons of beet processed in the Corporation's factories produced 620,317 tons of white sugar, 282,517 tons of pulp, and 214,006 tons of molasses. Since the war, an extensive programme of development and reconstruction has been carried out at the beet sugar factories, with a consequent improvement in operating efficiency. The Corporation's "efficiency barometer" shows, in fact, that whilst in 1945 the number of man-minutes per ton of beet worked was 137, by the end of last year's campaign that figure had fallen to 58. Similarly, in 1945 the quantity of coal used per 100 tons of beet worked was 10·42 tons, the comparable figure for last year being 7·79 tons. The factory development programme has included, in its later stages, many improvements to assist the speedier handling of the beet to be processed—a matter of considerable importance when the quantity to be dealt with each season is round about 5,000,000 tons.

Automatic Batching System

WE are informed by Henry Simon, Ltd., that demonstrations are to be held at the Cheadle Heath, Stockport, works of an automatic proportioning system which is designed for industrial use where materials are mixed in batches to a fixed or variable formula. This "Select-o-Weigh" system, as it is known, was originated by the Richardson Scale Company of the United States and is now being manufactured by Henry Simon, Ltd. The system brings an entire feeding, weighing, mixing and discharging cycle under the control of a central panel on which the weights of individual ingredients may be set up by manually-operated dials or by a punched card programming device.

In a typical installation each ingredient is stored in a separate supply bin fitted with an electrically-powered discharger. The dischargers feed into the weigh hopper of a dial scale and this hopper is also equipped with an electrically-operated discharge device. A device in the dial head sets up an electrical condition analogous to the angular displacement of the pointer. The remote control panel also contains the means of setting up an electrical equivalent of any desired weight for each ingredient.

When the equipment is started, the first ingredient feeds into the dial scale, the electrical condition of which is continuously compared with the corresponding condition set up on the panel. When the two coincide, feeding of the first ingredient stops and the feeders for the second and subsequent ingredients are automatically energised each in its correct sequence. On completion of the batch, the weigh hopper discharges automatically into a mixer, conveyor or other receptacle, and the system resets itself for the next batch, which may be automatically or manually initiated as desired.

The makers state that there are few limitations on the number, nature and quantities of the materials handled, and that up to a dozen ingredients can be handled by a single scale, whilst multiple scale installations can deal with far more complex formulations.

Industrial and Labour Notes

Exports

In a survey of the United Kingdom's overseas trade in September, the *Board of Trade Journal* says that exports of manufactured goods fell rather more steeply between August and September than did exports as a whole; exports of food were higher, and shipments of fuels were well maintained. Amongst manufactures, the Board explains, the sharpest decline was in engineering products, which represent the sector that has been most buoyant this year. Exports of ships and boats and railway vehicles were lower in September, and machinery showed about the "average decline." On the other hand, exports of road vehicles and aircraft were comparatively high for a short working month (twenty-four days). Exports of aircraft in September were unchanged from the August figure of £5,000,000, though they were still below the level of the first half of this year. Exports of cars and chassis in September were about 9½ per cent below those of August, but commercial vehicle exports were only "marginally lower." The Board's survey adds that, in the metals group, exports of non-ferrous metals in September, valued at £8,000,000, maintained the average level of the first eight months of this year. "Manufactures of metals," however, were a good deal lower, owing to reduced exports of arms and ammunition.

Investment in Manufacturing Industry

In the latest edition of *Bulletin for Industry*, the Treasury comments on investment in manufacturing industry, which is described as having been "very heavy" over the last eighteen months. After pointing out that this investment is providing a very necessary basis for the further growth of the economy, the *Bulletin* recalls that "it became so pronounced last year that it was adding to the inflationary pressure and to our balance of payments difficulties." Following the measures taken to check the investment boom, the Treasury says, the indications are that it may be beginning to moderate. Between 1954 and 1955 there was a 20 per cent increase in the volume of fixed investment in manufacturing, and there are indications that that rate of increase continued during the first half of this year. In fact, a sample inquiry made by the Board of Trade suggests that actual expenditure in the first six months of this year was about a quarter above that of a year earlier.

For 1956 as a whole, the *Bulletin* continues, the first estimate of the sample of manufacturing companies, made towards the end of last year, was that they would spend 17 per cent more than they expected to do in 1955; but in April their estimate was revised upwards to 21 per cent. This was made up of an expected increase in spending of 33 per cent on buildings and 18 per cent on plant, machinery and vehicles. About two-thirds of the 600 companies which contribute to the sample inquiry have made provisional estimates of their expenditure in 1957. From these it would appear that they do not expect to exceed this year's spending. Their expenditure on building work next year is expected to fall by 9 per cent, more than offsetting a small increase in spending on plant, machinery and vehicles.

It is acknowledged that, at this early stage, the forecasts for next year are uncertain and may to some extent be an understatement. The *Bulletin* suggests, however, that they do point to some levelling out in capital exepnditure in the manufacturing sector. This is supported by the smaller area of new industrial building for which approvals were sought and granted in the first half of this year, and by the drop in new home orders for machine tools. Approvals for industrial building, on an area basis, were lower than a year earlier by almost 10 per cent in the first quarter of this year and by over a half in the second; in the third quarter there was little change, and for the nine months considered together the drop, when compared with a year earlier, was about one-seventh. New machine tool orders from the home market, which were as high in the first quarter as a year earlier, were following suit in the second with a drop of one-quarter, although even that was not sufficient to reduce the total value of home market orders on hand. On the other hand, the *Bulletin* remarks, new home orders for capital goods in engineering generally seem to have been picking up in the second quarter of this year.

Railway Wages

Last week it was announced that the National Union of Railwaymen had decided to submit to the British Transport Commission a claim for a 10 per cent wage increase for its members employed on British Railways. This decision came after a meeting between the N.U.R. and the Transport Salaried Staffs Association to consider a joint wage claim. But it was stated subsequently that the Transport Salaried Staffs Association felt that the present moment was not opportune for making a claim. The executive of the N.U.R., however, was agreed that it must go forward with a claim, as directed by its annual delegate conference last July.

It will be recalled that the other railway union, the Associated Society of Locomotive Engineers and Firemen, has a wage claim which has not been settled. This claim, for a 15 per cent increase, has been rejected in the first two stages of the negotiating machinery. It has now been referred to the final stage, the Railway Staff National Tribunal, for arbitration.

The last increase in railway wages was made in January. All railway workers then received increases approximating to about 7 per cent on existing scales.

The Problem of Rising Costs

At the annual meeting of Crossley Brothers, Ltd., which was held in Manchester last Monday, the chairman, Sir Kenneth Crossley, Bt., spoke about the related problems of rising wages and costs. He said that the problems of costs and prices were the biggest which had to be faced by firms heavily engaged in export trade.

Since 1950, Sir Kenneth continued, wage awards in the engineering industry had amounted to a 53 per cent increase, against which his firm had reluctantly been compelled to put up selling prices by 37 per cent. That figure was substantially greater than those of principal overseas competitors. The never-ending wage increases, Sir Kenneth said, which the trade unions demanded and had had the power to obtain, had now gone to the limit; the point had been reached when they were in danger of pricing the engineering industry out of the export market, as was already evident in other industries. There was a growing feeling, Sir Kenneth added, that wise counsels no longer prevailed in responsible trade union quarters, and that too many employers, largely content in their home market, were prone to take the easy way out by conceding the trade union demands and raising prices to the home customers. As these wage increases were not accompanied by anything like a corresponding increase in productivity, Sir Kenneth remarked, the net result was the "unpleasant inflation" of which all were aware, and of which the exporting industries had to take the brunt.

Transport Commission's Design Panel

The British Transport Commission has appointed a panel, under the chairmanship of Mr. T. H. Summerson, "to advise on the best means of attaining a high standard of appearance and amenity in the design of equipment." This panel, it is stated, will be concerned with equipment of all kinds which is used by passengers, customers and staffs, or is "prominently visible to them or to the general public." The Commission says that it is anxious to make the most effective use of professional designers and consultants outside the transport industry as well as of its own staff designers, and one of the principal objects of the panel will be to assist in this matter.

The Commission says that its aim is that its new equipment shall be in line with the best current standards in industrial design, while preserving the dignity and simplicity appropriate to a great public service. This policy, it points out, applies more particularly to the modernisation plan for British Railways, and the design panel has been asked to give priority to this part of its work. The new equipment, the Commission adds, will be modern and highly efficient, and it is intended that those qualities should be clearly reflected in form and appearance. The Commission declares that if this can be achieved on the scale it has in mind, it believes that "one important result will be an increased sense of pride among the staff, and a new confidence in the future of the service on the part of both staff and public."

The Factory Inspectorate

At the beginning of last year, a departmental working committee was set up in the Ministry of Labour to examine, in the light of anticipated developments of policy and industrial organisation, the staffing and organisation of the factory inspectorate. Actually, the working party's function was to assist the Under-Secretary in charge of the Ministry's safety, health and welfare department, the Director of Organisation and Establishments, and the Chief Inspector of Factories, who were directed by the Minister to investigate the matter.

The results of the investigation, and the decisions arising from it, have been embodied in a White Paper (Cmd. 9879), which was published at the end of last week. Under the heading "Principal Decisions and Conclusions," it is suggested that no efforts of an exceptional kind need to be made to increase the recruitment of technically qualified persons to the general inspectorate, but, within the limits of present policy, "every effort should continue to be made to increase interest in the inspectorate among such persons." The main conclusion on the organisation of the Factory Inspectorate is that few changes are necessary; the division of the inspectorate into a general branch with specialist branches—engineering and chemical, medical and electrical—supporting and supplementing it, is considered to be sound. It is urged, however, that, while the engineering and chemical branch should continue to be based on the inspectorate's headquarters, a substantial number of the inspectors should be stationed in the divisions. To achieve that, and to provide for a small increase in the numbers at headquarters, it is recommended that the strength of the engineering and chemical branch should be approximately trebled "by such stages as are practicable in relation to recruitment and absorption."

Another decision is that an average of two new inspectors per division, making twenty-six in all, should be added to the establishment to improve the inspection of building sites and engineering construction works. The purpose of this, the White Paper says, is "to permit greater frequency and thoroughness of inspection in this important sector."

"Men, Management and Metal"

The Council of Ironfoundry Associations is to hold a conference, under the title of "Men, Management and Metal," at the Royal Empire Society, Northumberland Avenue, London, W.C.2, on Wednesday, November 7th. The conference will be attended by representatives of management, the object of the day's deliberations being to focus attention on the qualifications essential to those who will control and supervise foundry businesses in the future. Sir Harold West, who is to preside at the conference, has pointed out that, for the ironfounding industry, the need is not merely to increase the number of people undergoing training on traditional lines, but to determine what new forms of training and what new experience may be needed to equip men for positions of management and technical control in the immediate years ahead.

European Coal and Steel Community

No. I

IT is now five and a half years since the treaty establishing the European Coal and Steel Community (C.E.C.A.) was signed in Paris on April 18, 1951, and over four years since this fifty-year treaty came into force on July 25, 1952. As will be recalled, the setting up of the Coal and Steel Community had its origins in the proposal by the French Foreign Minister, Monsieur Schuman, on May 9, 1950, that all French and German coal and steel production should be under a common authority, in an organisation to which other European countries could also be admitted.

The organisation comprises the Council of Ministers, consisting of one representative from each of the member states, with the object of harmonising the various national interests ; the General Assembly, which exercises parliamentary control over the High Authority ; the Court of Law, comprising seven judges, each nominated by the governments irrespective of nationality, and for six years ; and the High Authority, with its seat in Luxembourg.

The General Assembly, which first met in September, 1952, has seventy-eight members, who are designated once a year by the various national parliaments. Belgium has ten delegates, France eighteen, of whom three represent the Saar, Germany and Italy eighteen each, Luxembourg four, and the Netherlands ten.

The High Authority has nine members, who were nominated for six years from the establishment of the common market for coal, ore and scrap in 1953, i.e. until February 9, 1959. The members act independently. At the start eight were selected unanimously by the six governments, while subsequent elections can be decided by a 5/6 majority, the veto of the minority country being subject to the decision of the Law Court. The ninth member is to be co-opted. Decisions are taken by the High Authority on a majority vote, not subject to veto. In its work the High Authority is aided by an advisory committee of fifty-one persons, whom it nominates in equal numbers from the organisations representing producers, users, trade, and workers.

Once a year the High Authority submits a report to the General Assembly, which can by a two-thirds vote of censure force the Authority's resignation. The Authority also has to keep the Consultative Committee informed of its general objects and the broad outline of its policy. The Committee must be consulted on certain points and can be consulted on any question. In order to achieve the Treaty objectives the High Authority is empowered to take decisions which have the force of orders in all details, to formulate recommendations, which must be obeyed but which leave the means to the choice of the recipient ; and to give advice which it is not compulsory to follow.

On November 17, 1955, an agreement was signed between the Community and the United Kingdom, establishing a Council of Association consisting of a member of the British Government, a member of the National Coal Board and a member of the Iron and Steel Board, on the one hand, and three members of the High Authority, on the other. The Council established three permanent committees, which deal respectively with commercial relations, with steel, and with coal. It meets alternately in Luxembourg and in London and maintains a joint secretariat. Its purposes are consultation and co-ordination of action in matters of common interest pertaining to production and trade in coal fuels, iron and steel and their raw materials, investments, and the development of other sources of energy as far as this affects coal and steel, technical research, safety, health and welfare.

The Agreement stipulates that any additional restrictions on iron or steel exchanges by any of the parties must be notified to the Council beforehand, if possible, or immediately afterwards, so that co-ordinating action can be taken. Present restrictions and other factors such as tariffs, are to be examined with a view to their reduction or abolition.

Preparatory Period

The history of the Iron and Steel Community from July 25, 1952, to the end of last year,*† falls into two sections : the preparatory period and the period of transition.

The preparatory period began with the coming into force of the treaty and ended with the establishment of a common market for the various products mentioned in it. This took place on February 10, 1953, in the case of coal, iron ore and scrap iron, and on May 1, 1953, in the case of steel. The second period, of transition, which is due to end on February 9, 1958, is concerned with economic integration.

The first plenary session of the General Assembly took place from September 10–13, 1952, at Strasbourg. On the invitation extended by Chancellor Adenauer on behalf of the Foreign Ministers of the six countries, the Assembly, on September 13, constituted itself as an *ad hoc* assembly for the purpose of drafting before March 10, 1953, a treaty establishing a European Political Community. The first meeting of the Ministerial Council took place on September 8 and 9, 1952, at Luxembourg, and the Court of Law came into being at Luxembourg on December 4, 1952. On January 15, 1953, the Consultative Committee was set up.

Negotiations with third countries, notably Great Britain, began with the coming into force of the treaty, and a British delegation was received at Luxembourg on September 1, 1952. The next day, a United States delegation was similarly received. These had been instructed by their governments to investigate means for a closer association. A joint committee was set up, which first met on November 17, 1952, on which Great Britain and the Authority were represented.

In order to reinforce the co-operation between the Community and the Council of Europe, the High Authority declared its readiness to delegate one of its members to give any information required about the Community to the Ministerial Committee or to the Consultative Assembly. It also attended two meetings of the Consultative Assembly's Commission on Economic Affairs. A permanent mission was sent to the O.E.E.C. Coal and Steel Committees.

Both GATT, in its decision of November 10, 1952, and O.E.E.C. recognised the Community countries as one single economic unit as far as coal fuels and steel were concerned.

The High Authority immediately commenced its task of establishing the common market, by examining with the governments concerned the distortions due to local legislation, and by convening a commission of experts for investigating freight differentials. Notification of charges on subsidies for coal and steel were requested, with a view to fixing dates after which such subsidies or charges would be discontinued, unless special permission was given by the Authority. In the same way, the first steps were taken towards the dissolution of monopolies and price rings. It was, however, decided that such delicate legislation required very careful preparation.

Measures leading to the establishment of the common market concerned the building up of equalisation procedures, the suppression of quantitative restrictions and tariff barriers, and the elimination of discriminatory transport charges. In its decision of May 2, 1953, the High Authority gave these four rules : uniformly applied price schedules, prohibition of discrimination on grounds of nationality or location, prohibition of basing individual quotations on tonnage or value, and prohibition of passing on to the consumer any taxes or dues from which the seller has the right to be exempted.

The treaty also provides that the member countries should increase productivity by creating a better division of production. To this end, the Authority took steps to suppress administrative rights and bureaucratic formalities which tended to hinder free internal exchanges.

With the coming into force, on February 10, 1953, of these measures there was established the Common Market for coal, ore and scrap iron, to be followed two months later by steel.

The Transitional Period

The existence of a common market has given rise to numerous problems, such as co-operation between governments of the member states ; investments, production agreements and concentrations ; labour questions; transport, technical and economic research, and external relations. General directives as to how these should be approached were already contained in the treaty.

In order to enable it to carry into practice the general principles of the treaty, the High Authority, as stated in its memorandum of July 6, 1955, has carried out studies of the results achieved, as well as for the purpose of putting into effect new practices, in particular in the field of utilisation. In collaboration with the joint committee, it has sought to estimate the future trend of the various national economies and the effects of such developments on coal and steel in competition with other materials or forms of energy. Expert commissions have been set up for the study of economic, technical and social questions, and for giving precise and detailed definitions which would permit the treaty principles to be applied in practical cases.

Forecasts of consumption and exports on which the Authority is basing its plans are (according to the memorandum quoted) 52,000,000 tons per annum of crude steel for home consumption and export, by 1958. This target will very likely have to be raised to 57,000,000 tons. The lower of these figures would suffice for 41,000,000 tons of cast steel, while the higher figure would yield 45,000,000 tons.

A steel production of 52–57 million tons would require ore with 31–35 million tons of iron content. For a production of raw ore, in 1958, amounting to 86–87 million tons, with some 25,500,000 tons iron content, imports would increase to 18–20 million tons of raw ore per year, representing an iron content of 10–11 million tons. No difficulties in obtaining sufficient ore are anticipated.

As regards coal consumption, the situation is regarded as in a state of flux owing to the competition from other forms of energy. It was very important, the memorandum says, to keep coal prices as low as possible. A production within the Community of 260–265 million tons in 1958 is thought possible ; this represents an increase of about 20,000,000 tons over 1954, which is apportioned thus :—

Ruhr	11–13 million tons
Aix-la-Chappelle	1 million tons
Lorraine	3 million tons
Saar	1–2 million tons
Belgium	1–2 million tons

Estimates for additional requirements of coke vary between 10,000,000 to 11,000,000 and 14,000,000 to 15,000,000 tons.

Production in 1952–55

Production of treaty products in the Community as a whole reached an all-time record in 1955 and is still increasing, although the limit of capacity is stated to be now in sight. Figures for hard coal, iron ore and crude steel are shown in the accompanying table. Since the manpower

* *Annuaire-Manuel de l'Assemblée Commune*, 1956. By the Division des Etudes et de la Documentation de la Communauté Européenne du Charbon et de l'Acier, Service de Publications de la Haute Autorité de la C.E.C.A., 27, Rue Aldringer, Luxembourg. Price Fr. b. 100 (Fr. f. 700).

† *Towards European Integration. First Results for Coal and Steel.* Published by the High Authority of the European Coal and Steel Community. Information Service of the High Authority, 27, Rue Aldringer, Luxembourg.

remained practically unchanged, the output per man-shift appears to have gone up considerably.

TABLE I—*Production of the Community*, 1952–55. (*Millions of Metric Tons*)

Year	Hard coal	Iron ore	Crude steel	Total, 1952=100
1952	238·9	65·3	41·8	100
1953	237·0	66·2	39·7	97
1954	241·7	65·0	43·8	103
1955	246·4	76·1	52·7	115
Increase, per cent				
1952/55	3·1	16·5	26·1	14·6
1955/56*	1·8	8·2	8·6	5·4

* First quarter

TRADE

From 1952 to 1955 the volume of trade in Community product, at 1952 prices, increased by 93 per cent, while trade between Community countries in all other products went up by only 59 per cent. This is indicated in Table II,

TABLE II—*Trade Between Community Countries* (*at 1952 Prices*). 1952=100.

Year	Coal	Iron ore	Iron and steel products	Scrap	All treaty products	Other products
1953	111	112	127	225	121	115
1954	125	117	191	434	160	138
1955*	140	137	251	457	193	159

* First six months

which shows how the introduction of the Common Market has helped to expand trade as compared with the liberalisation policy which was operated in the case of the other products. While time is yet too short to permit a study of full trade cycles, it may be said that while during previous boom periods trade either went down as production went up, as in 1927–29, or at least failed to keep pace with it, as in 1935–37, in the Common Market from 1953 to 1955 trade increased three times as fast as production, thereby lessening supply difficulties.

PRICES

The development of prices of coal, iron ore, scrap and steel has been equally steady. Abolition of dual pricing between treaty countries has resulted in lower prices for these products, compared with 1952, than for all other raw materials, semi-manufactured and manufactured goods and foodstuffs which do not fall under the Treaty (see Table III).

TABLE III—*Average Prices in Trade Between Community Countries*. 1952=100.

Year	Coal, coke, briquettes	Iron ore	Scrap	Iron and steel	All other products
1953... ...	98·5	99·1	68·7	75·7	96
1954... ...	94·1	94·0	57·3	67·3	92
1955* ...	91·8	90·3	68·6	73·3	89

* First six months

REGIONAL REGROUPING

Since the Common Market was first introduced there have been many regroupings, mostly aiming to rationalise the flow of traffic. On the whole the flow of trade has shifted slightly in an anti-clockwise direction. The Ruhr and Lower Saxony are delivering more coal to the Netherlands and comparatively less to South Germany. The Limburg coalfield and Belgium are delivering increased tonnages to the South, in particular to France, while France and the Saar are delivering to Southern Germany. This change has resulted in considerable transport economies.

Imports of steel into Southern Germany have shown a sharp increase in relation to total purchases, both absolutely and as a percentage (1952=14 per cent, first half 1955=34 per cent).

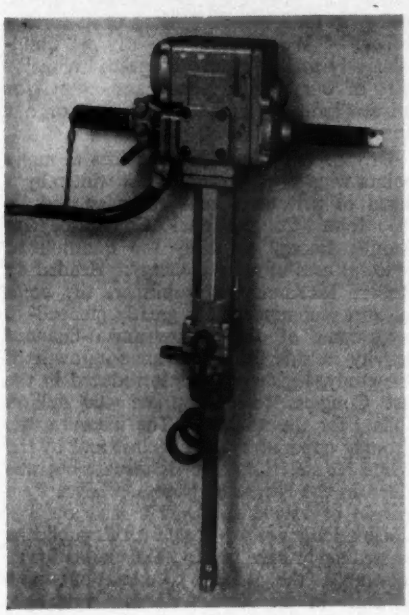
Reduction in transport costs has resulted from the abolition of discrimination and the introduction of through rates. This reduction has in some instances amounted to as much as 27–29 per cent.

(To be concluded)

Electric High-Frequency Power Drill Hammer

In the accompanying illustration we show a high-frequency drill which is being manufactured by Robert Bosch G.m.b.H., Stuttgart. It operates on 200 c/s, three-phase current. The four-fold increase in frequency permits a reduction in size and weight to one-third or one-quarter of that of a standard frequency motor.

The 200-cycle current is derived from a frequency converter operated from the 50-cycle mains, or else a diesel engine motor generator set can be used. Robert Bosch makes an 8·7 h.p., 5kVA, wheel-mounted set which weighs 230 kg. The first possibility is used in coal and other mines, the second is more suitable for building sites. This set can supply two percussion drills or four track tampers. It is stated that operation is not affected by height above sea level or by low temperatures. The generator also supplies current for lighting at 220V or 110V, in addition to the drill supply, which is at 265V, or, where the regulations require it, 120V. The U.K. agent is Burton, Griffiths and Co., Ltd., Small Tools Division, P.O. Box 232, Birmingham, 11.



High-frequency drill hammer for operating on 265V or 120V, three-phase, at 200 c/s

Tubular Steel Dolphin

On account of their greater strength, tubular steel dolphins for the mooring of ships have of late years taken the place of wooden dolphins to an ever-increasing extent. A novel application of dolphins is their use as offshore tanker stations for loading oil or discharging it, e.g. at refineries which have not a sufficiently developed range of quays or of approach channels at their disposal.

A tanker discharge station was constructed in the Adriatic by Mannesmann for one of the largest Italian refineries, the Societa Azionaria Raffinazione Olii Minerali (SAROM), of Ravenna, whose plant lies 5km inland. This station was built 6·3km distant from the shore, in the form of a large tubular steel dolphin, which was equipped with a crane installation supplied by Eggers-Kehrhahn, Hamburg.

This construction, which has a diameter of 15m, consists of thirty-six seamless mild steel tubes each measuring 32·9m in length, with an external diameter of 521mm and a wall thickness of 15mm ; it carries two platforms. In these platforms a rigid crane column is fixed, on which is mounted a rotating jib. The jib is equipped with four electrically operated cable lines for the manipulation of the flexible hoses. Thus the hoses can be brought right up to the pipe connections of the oil tanker, which can be moored in any direction relative to the dolphin platform, as the crane has a slewing range of 360 deg. One 16in pipeline and two 8⅝in pipelines for crude oil, fuel oil and kerosene, as well as a 3in water pipe—all supplied by Italian firms—connect this Adriatic island with the refinery.

Besides the fact that a single operator is able to manipulate the flexible hoses, a further advantage which generally applies to the dolphin design is that large tankers, which up to now have not been able to proceed into inner harbours and thus had to have their cargo handled by lighters, can be moored several at one time, if supplementary crane equipment is installed, at a single dolphin without the aid of a tug and can thus discharge and load directly. This also saves the high harbour charges.

Straightening of Bent Reinforcing Rods

A simple arrangement for the straightening of old reinforcement rods or thick wire is described in E.P.A. Digest No. 652. The tooling consists of a thick-walled steel pipe, is bent and then hardened. The bend takes the form of a kink with the straight inlet and outlet positions remaining in alignment, the pipe at the kink itself being displaced by half a diameter.

The pipe is clamped in the chuck of a lathe. The headstock spindle must, of course, be hollow in order to allow the reinforcing rod to pass through. If a bent rod is pushed through the pipe whilst the lathe rotates at high speed, it comes out again at the rear of the headstock, completely straight. In this way reinforcing rods with diameters of 6mm to 12mm, can be straightened. The diameter of the pipe depends on the thickness of the iron rod, e.g. for a 6mm rod a ¼in pipe must be used. In the case of thicker rods (e.g. 12mm) the friction which occurs in the pipe makes it more difficult to pass the rod through. To reduce friction, a hardened steel roller is fitted in a slot which is made in the pipe on the inside of the bend. For stiffening the pipe, a bridge piece is welded on. If no lathe is available, it is possible to mount the bent pipe between bearings and drive it by means of a pulley.

Tubular Steel Tower

On the occasion of this year's Vienna Autumn Fair, a tower built of steel tubes and standing 150m high was erected at the site of the Fair by Mannesmann A.G., Düsseldorf. It is similar in design to other "Mannesmann Towers" in Düsseldorf, Hanover, Sao Paulo, and elsewhere, but is the highest one built to date. Triangular in plan, the tower stands on three blocks of concrete of 75 cubic metres each, which are sunk to a depth of 4m. The tower's edges are parabolic in shape. The steel structure consists of prefabricated tubular elements, made from tubing varying between 121mm by 4mm and 318mm by 18mm. Assembly of these components, which have a total weight of 55 tons, is stated to have taken just over one month. The low weight of the tower contrasts strikingly with that of corresponding structures built from steel sections. The 300m Eiffel tower, for example, weighs about 7000 tons, while a tubular steel tower of the design described and of equal height would weigh only about 200 tons.

Utilisation of Swiss Hydro-Electric Power

The Association Suisse pour l'Amenagement des Eaux, in a recent brochure, draws attention to the importance of an efficient utilisation of the reserves of water power in Switzerland. It states that the greater portion of the hydro-electric energy which is produced in the country is consumed in households, agriculture and small-scale industry. Under these heads a total of 36·4 per cent was consumed last year, while the railways used 19·8 per cent, large-scale industry 15·9 per cent, and metallurgy, chemical industry and thermal power stations together 19·8 per cent.

Since the beginning of the century annual electricity production in Switzerland has increased from 200 million to 13,000 million kWh. If account is taken of all aspects of electric power production, about 70,000 persons are employed in Switzerland in this field.

The American Scene

BY OUR AMERICAN EDITOR

"THE BENEFICENT ATOM"

WHAT Mr. Lewis L. Strauss, the chairman of the United States Atomic Energy Commission, called "the bounties of the beneficent atom" was the subject of perhaps the largest conference in the entire history of international collaboration, which opened at the United Nations in New York City at the end of September. Representatives from eighty-one states were present, including the Republic of Korea, the German Federal Republic and Vietnam. Both Mr. Strauss and secretary general Harmmarskjold referred in their welcoming addresses to the speech in which President Eisenhower, on December 8, 1953, proposed an international agency for the pooling of fissionable materials for peaceful uses. The President said at that time: "It is not enough to take this weapon out of the hands of the soldiers, it must be put into the hands of those who will know how to strip its military casing and adapt it to the arts of peace." Since that December day, nearly three years ago, much that is disheartening and terrible has happened. New issues have arisen all over the world. But this much may be said on behalf of the United States: there is no responsible spokesman for either of the major political parties who would not say amen to-day to what Mr. Eisenhower said in 1953. When a Russian speaks of the atom, as did Mr. Bulganin in his message to the conference, one may expect a plug for Russia's supposedly superior interest in peace and in "the prohibition of atomic and hydrogen weapons." But, all such politics and propaganda aside, one may go along with the Russians' hope for "the development of international co-operation in the field of the peaceful uses of atomic energy, based on the principles of the equality of states and observance of their national sovereignty."

However, even while Mr. Strauss was welcoming the United Nations conference, his administration of the A.E.C. came under renewed domestic attack for the deliberately slow pace with which the Commission is pursuing its "atoms for peace" programme. What troubles his critics is that the United States, who is supposed to lead all other nations in the technical mastery of nuclear energy, has not done more than she has to put this new power source to constructive peaceful uses. Specifically, the complaint is that America is "losing the race" for electric power generated from atomic fission to others, with consequences that are both political and economic in their cost. The most recent—and in some respects the most authoritative—criticism made of United States policy in this field has come from Henry DeWolf Smyth, a former member of the A.E.C. Writing in *Foreign Affairs*, a quarterly journal, Dr. Smyth sharply questions the wisdom of gearing atomic power development to the dictates of "economic realism," which he asserts the Commission has done. "We do not have a single plant in operation," he says, "producing significant amounts of commercial power from nuclear energy. One such plant is under construction. Others are planned, but the future of such plans is clouded by controversy arising out of the old public versus private power issue." Dr. Smyth maintains that though the United States has less pressing reasons than many other nations to find a quick substitute for coal and oil as energy sources, the country should, nevertheless, speed the perfection of nuclear electric energy to fulfil the obligations of its foreign policy. "We cannot," he says, "simultaneously make 'atoms for peace' a major part of our foreign policy and atoms for private industry a controlling part of our domestic policy."

Dr. Smyth's complaint coincides at many points with a report issued last winter by a panel of private citizens commissioned by the Joint Congressional Committee on Atomic Energy to study the question of peaceful uses of atomic energy. Headed by Robert McKinney, a publisher, the commission recommended a greatly stepped-up programme of direct Government-financed activity in this field. As an outgrowth of this study, legislation was introduced in the last Congress to appropriate 400 million dollars for the purpose. The measure was strongly opposed by Mr. Strauss and by the White House. It passed the Senate but was killed in the House of Representatives by a margin of twelve votes. The division was along strictly partisan lines, with Republicans massed against the bill and Democrats for it. Inevitably, the issue has come out prominently in the current election campaign, and both Stevenson and Kefauver are hammering it home. At the centre of this controversy is Mr. Strauss, who is not only the chief of the Atomic Energy Commission but also the President's official adviser on atomic energy policies. Mr. Strauss's thesis, simply stated, is that technology should precede construction, that since the nation is not faced directly with a power crisis, it should not invest exorbitant sums for power plants that are certain to be not only uneconomical competitively, but technically obsolete even before they are completed. What America should do, he asserts, and what she is doing, is to proceed as rapidly as prudence permits with prototype power plants built in "partnership" with private industry. The power generating aspect of the new science, he argues, is the natural domain of private industry and industry should be brought into the picture as promptly as possible. And as industry acquires experience in the building and management of these prototype plants, it will be prepared to undertake full-scale operations when and as their construction becomes feasible. As an indication that this programme is not lagging, the chairman produced, the other day, statistics showing that the commission is involved in seventy-six projects for power reactors either built, under construction or in negotiation for completion within five to eight years. Forty-three of these are for military purposes and thirty-three are under civilian auspices. In spite of these figures, the feeling is growing in Washington that Mr. Strauss has become a political burden to the Eisenhower Administration. Even those who have the highest regard for Strauss's ability point out that he has been less than effective in his public relations. Thus, the President may well feel that Mr. Strauss is too big a liability to carry. It is true, the President has stuck by agriculture secretary Benson and defence secretary Wilson, but in these cases he believes implicitly in their programmes. On the other hand, he was not unwilling to let secretary McKay go when attacks on the Department of the Interior gained momentum.

Medical Irradiation Facilites at M.I.T.

A GRANT of up to 250,000 dollars from the Rockefeller Foundation to the Massachusetts Institute of Technology will give New England important facilities for medical treatment and research in the nuclear reactor which is now under construction at M.I.T. This grant is in addition to a grant of 500,000 dollars from the National Science Foundation for the construction of the reactor. The medical and biological facilities of the new M.I.T. reactor—for which the Rockefeller grant is to be devoted—will be centred in a therapy room, situated underground directly beneath the reactor itself. Neutrons from the fission in the reactor will enter the room through the ceiling in a beam directed downward. The M.I.T. reactor is one of the few reactors in which such a downward directed beam will be available.

The therapy room will, in effect, be a large and completely equipped operating room. It is being designed to serve all medical organisations in Greater Boston and to be adequate for all applications which can now be foreseen for neutron and gamma-ray therapy. Since the therapy room is designed as an operating room, irradiation of patients immediately after surgery will be possible. In general, three types of medical treatment and research will be made possible for medical scientists by the reactor at M.I.T.: (1) neutrons or gamma-rays from the reactor may be used directly to irradiate tumours in patients brought to the medical therapy room; (2) many basic studies of the effects of neutrons or gamma-rays on living tissue will be possible in the therapy room or in other experimental facilities; and (3) the reactor's neutrons will be used to make many neutron-produced short-lived isotopes which have never before been available in New England. These will be important both in research and in medical treatments.

An interesting aspect of the medical therapy room in the M.I.T. reactor facility will be a shutter by which the beam of neutrons entering the room can be turned on and off at will. It will consist of a large tank of water, which will absorb most neutrons, and a plate containing boron, which also absorbs neutrons. Opening the shutter will consist of pumping the water out of the tank and sliding the boron plate out of the path of the neutron beam. Directly beneath the shutter will be the medical facility's surgical operating table, completely movable so that any part of a patient on the table may be positioned under the aperture for neutron irradiation. The medical facilities room will be about 12ft square and 7ft 6in high. Adjoining it will be a control area, where the medical staff will be stationed during the irradiation of patients. Here will be the controls for the shutter and the operating table position. A 4ft 6in thick glass tank of zinc bromide solution will permit observations of the therapy room, and there will be electrical circuits for communication with the patient.

An immediate use of the medical facilities will be a new treatment for cancer of the brain, developed by Dr. William H. Sweet, of the Massachusetts General Hospital; Dr. Gordon Brownell, of M.I.T.; and Dr. Lee Farr, of the Brookhaven National Laboratory. By this method a patient with a brain tumour is given a

compound of the element boron. The compound moves through the body and concentrates rather selectively in the cancerous tissue in the brain region. Thermal neutrons streaming through the aperture from the reactor penetrate the cancerous area and cause the boron to release alpha particles. These damage or destroy cancerous tissue in their path.

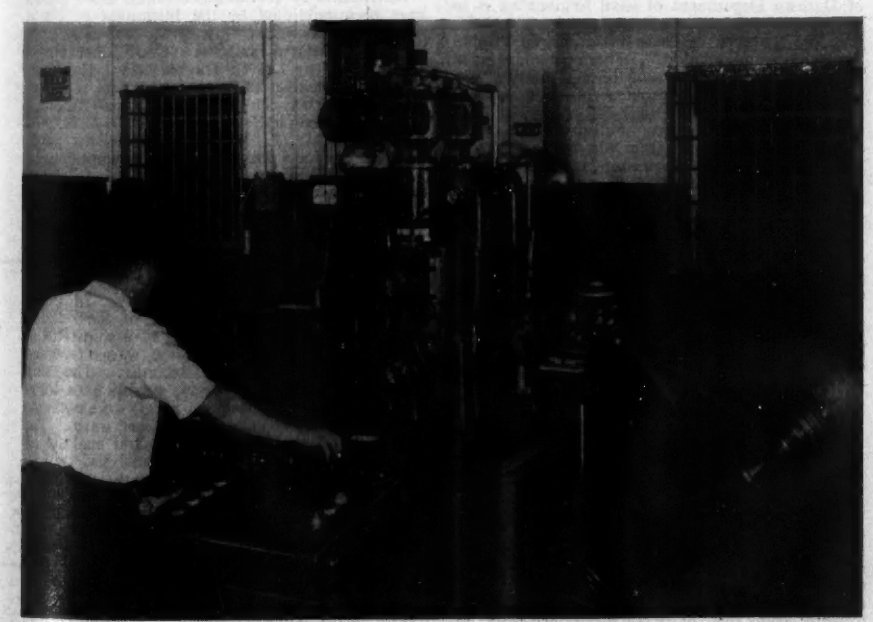
Backup-Driven Four-High Cold Strip Rolling Mill

THE illustration reproduced below shows an interesting four-high reversing cold strip mill, which has been developed by the Stanat Manufacturing Company, Incorporated, of Long Island City, New York. The machine was designed specifically to fulfil moderate output requirements in the production of close-tolerance and thin-gauge strip up to 8in wide and its applications include the processing of both ferrous and non-ferrous materials, such as carbon and stainless steels, beryllium copper, titanium, and aluminium alloys. The mill operates at speeds up to 500ft per minute and holds thickness tolerances as close as plus or minus 0·0001in consistently.

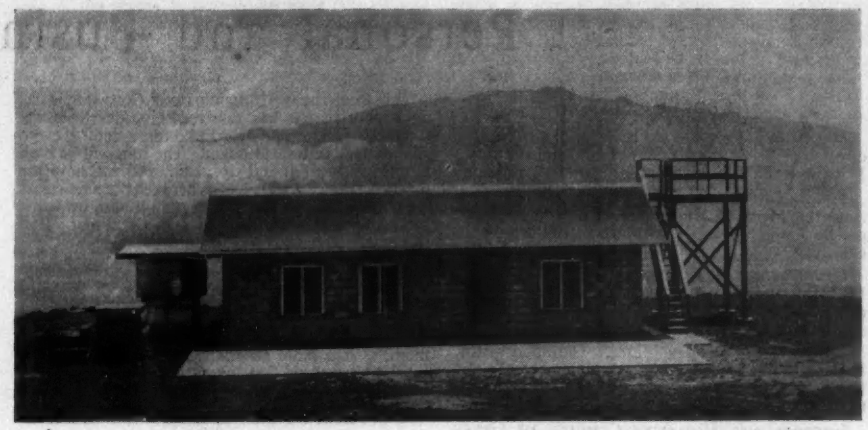
Rapid roll changing, within twenty minutes, is facilitated by the backup roll drive employed, which also offers the important advantage of change in work roll diameter without affecting the linear rolling speed of the mill. To handle a 0·125in to 0·001in range of strip, work rolls from 2½in down to ½in diameter can be employed. The rolls of the mill are made of vanadium alloy tool steel, hardened to Rockwell C-64 minimum and ground and polished to a high finish. The backup rolls are 8in diameter, the work rolls are 2½in diameter maximum, and both are available in either an 8in or a 10in face width. Roll wipers and run-in and run-out tables, equipped with adjustable side guides, are provided on the machine. The roll housings are steel castings, capable of taking heavy separating loads with minimum deflection. The rolls are driven through torque arms from a totally-enclosed pinion stand. The elimination of roll marks is achieved by hardened alloy steel double helical gears running in an oil bath, with loads being carried by heavy-duty tapered roller bearings. Heavy-duty universal joints connect the torque arms to the rolls and the pinion stand.

Radial rolling loads are taken by heavy-duty needle roller bearings, equipped with bronze cages, and axial movement is controlled by ball thrust bearings. The backup roll bearings have a maximum separating load capacity of 150,000 lb. Roll adjustment is made by a motorised screwdown system operating at a rate of ¼in vertical travel per minute and consisting of two 1 h.p. gear motors controlled electromagnetically to obtain individual or simultaneous "up" and "down" operation.

Two coiler stands, equipped with solid or collapsible drums, are driven by individual motors at winding speeds synchronised with the mill speed to obtain constant tension regardless of line speed or coil build-up. The mill is driven by a d.c. system comprising one 20 h.p. mill motor and two 20 h.p. coiler motors of infinitely variable speed. The electrical equipment also includes an operator's control panel, a packaged power unit, and electronic tension controls. Other interesting aspects of the mill are a bearing lubricating oil circulating and filtering system, a strip coolant circulating system, quick-acting strip bridles, and Pratt and Whitney continuous thickness gauges calibrated in 0·0001in. Constituting a compact, fully wired package unit requiring no elaborate foundations, the mill with coilers occupies only 10ft by 8ft of floor space.



8in wide "Stanat" backup-driven four-high cold strip rolling mill



High-altitude observatory on the slope of Mauna Loa in Hawaii

Dedication of Mauna Loa Observatory in Hawaii

A HIGH-ALTITUDE observatory on the slope of the Hawaiian volcano, Mauna Loa, was dedicated recently for joint use by the National Bureau of Standards and the U.S. Weather Bureau. Situated at a height of 11,134ft in the tropics, where the upper atmosphere is very clear and usually of low moisture content, the new observatory offers special advantages for many astronomical and upper-air studies. It will make possible a continuous observation of atmospheric phenomena with manned instruments in place of the unmanned meteorological balloons that have been used for the most part in high-altitude work.

The new observatory is expected to provide valuable data in a variety of fields. Its advantages as a high-altitude observatory are due largely to the fact that it is situated well above the bulk of the dust and moisture contained in the earth's atmosphere. At the latitude of Hawaii a "trade wind inversion layer" usually traps the dust and moisture below about 8000ft. Other important advantages of the Mauna Loa observatory are its ready accessibility and relatively warm climate. Most of the other comparable observatory sites are buried in snow during winter and part of the summer. Furthermore, the Mauna Loa observatory has the required altitude without the ruggedness that imparts turbulence to the surrounding air, and it is situated at a key point for studying the huge air masses of the tropics. The chief research results to be expected from the observatory are improved long-range weather forecasting and a greater knowledge of solar and atmospheric radiation. Because the air masses of the Pacific are responsible for much of the weather that occurs in other parts of the world, data on these air masses may make it possible to forecast conditions in distant places. There is some evidence that the ozone content of the lower atmosphere in the tropics is associated with the formation of the large low-pressure areas that produce typhoons. A continuous measurement of atmospheric ozone may thus be of assistance in forecasting typhoons.

The observatory also offers possibilities for the study of cosmic rays, total solar radiation, snow crystals, air glows, and radioactive fall-out. In July, the N.B.S. began a study of the moisture content of the planet Mars under the auspices of the National Geographic Society. They used spectroscopic techniques to investigate the light reflected to the earth from Mars. The advantageous site of the Mauna Loa observatory made it possible to reduce the effect of the earth's atmosphere on the planet's spectrum. During the coming year the N.B.S. expects to begin a study at Mauna Loa on the distribution of the spectral energy from the sun. Such information will be of value in determining the effect of the run's "rays in connection with high-altitude equipment, space flights, and man-made satellites. This work will also furnish data on the solar constant and information on solar intensities which may be useful in many fields.

The observatory is a concrete block structure and is situated about 2500ft below the summit of the mountain. The building contains five rooms in addition to a tower and a broad open platform for observational use. The present accommodation permits the use of the buildings by a maximum of six observers simultaneously.

Personal and Business

Appointments

MR. GEORGE TEASDALE has been appointed London director of The Villiers Engineering Company, Ltd., Marston Road, Wolverhampton.

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION states that Mr. J. W. Elliott has been elected chairman, and Sir James McNeill, vice-chairman, of the research council.

DAVID BROWN INDUSTRIES, Ltd., Tractor Division, Meltham, Huddersfield, announces the appointment of Mr. A. S. Heggie to the newly-created post of sales promotion manager.

BLACK AND DECKER, Ltd., Harmondsworth, Middlesex, announces the appointment of Mr. Robert Appleby as managing director, in succession to the late Mr. J. V. Franklin.

INTERNATIONAL HARVESTER COMPANY OF GREAT BRITAIN, Ltd., has announced the appointment of Mr. Michael Teale as sales representative for Scotland and the nothern part of England and Wales.

THE BRITISH TRANSPORT COMMISSION states that Mr. P. R. Salisbury, A.M.I.N.A., has been appointed assistant shipbuilding officer at headquarters. For the past five years he has been on the ship surveying staff of Lloyd's Register.

GEORGE ELLISON, Ltd., Perry Barr, Birmingham, 22B, states that Mr. Frank Mullis has been appointed chief inspector of switchgear. He succeeds Mr. James Allen, who is retiring after forty-three years in the company's service.

SIR JAMES MCNEILL, deputy chairman and managing director of John Brown and Co. (Clydebank), Ltd., has been re-elected president of the Shipbuilding Conference. Mr. J. A. Milne, chairman and managing director of J. Samuel White and Co., Ltd., has been re-elected vice-president.

BRITISH RAILWAYS announces the following appointments: Mr. W. Grant, A.M.I.C.E., district engineer (Sheffield), Eastern Region; Mr. P. Gray, carriage and wagon works manager, Stratford, Eastern Region; Mr. L. Ledger, assistant to stores superintendent (purchasing), Eastern and North Eastern Regions, King's Cross.

ESSO PETROLEUM COMPANY, Ltd., 36, Queen Anne's Gate, London, S.W.1, has established a development (operations) department. Mr. E. Evans-Jones has been appointed manager of the department. Other appointments in the department are: Mr. G. A. Vickers, manager of development engineering; Mr. R. L. Hill, manager of budget control; Mr. J. F. Biden, manager of distribution planning.

Business Announcements

MR. T. G. HICKS, managing director of Power Jets (Research and Development), Ltd., is making a tour of Canada and the U.S.A.

BIRLEC, Ltd., Erdington, Birmingham, 24, has acquired a thirty-four-acre site at Aldridge, near Birmingham, on which a new factory is to be built.

THE OWEN ORGANISATION announces the formation of Hill Alzen (Sales), Ltd., as a subsidiary of C. and L. Hill, Ltd. It will promote the sales of "Alzen 305" bearing metal.

SIEMENS-SCHUCKERT (GREAT BRITAIN), Ltd., Faraday Works, Great West Road, Brentford, is now the sole agent in the United Kingdom for Siemens-Schuckertwerke, A.G.

PETTERS, Ltd., states that The Southampton Launch and Boat Company, Ltd., Bitterne Manor, Southampton, is a sales and service agent for Petter marine diesel engines.

MANCUNA ENGINEERING, Ltd., Denton, Manchester, states that its London sales and design office has been moved to 59, Victoria Road, Surbiton, Surrey (telephone, Elmbridge 9793). Mr. R. A. Le Page is the manager of the office, and Mr. N. S. Stedman, who has recently joined the staff, is responsible for the design work.

Contracts

RICHARD SUTCLIFFE, Ltd., Horbury, Wakefield, has received an order from The Steel Company of Wales, Ltd., for wharfside raw materials handling equipment. This order, which is valued at over £200,000, includes 1340ft of 60in wide belt conveyor, a 60in wide shuttle conveyor, an 84in wide cross conveyor and supporting steelwork.

THE BURNTISLAND SHIPBUILDING COMPANY, Ltd., announces that it has received an order from the Grand Union (Shipping), Ltd., for a motor cargo ship of 1330 tons deadweight. The ship will be built by Alexander Hall and Co., Ltd., and will have the following dimensions: length between perpendiculars 199ft 10in, breadth 33ft 6in, depth 14ft 4in, while the propelling machinery will be a British Polar diesel engine of 750 b.h.p.

ACCLES AND POLLOCK, Ltd., a constituent firm of Tube Investments, Ltd., has received an order to produce the fuel element sheaths for the Dounreay Experimental Fast Fission Reactor. The order, which requires the production of niobium (or columbium, as it is more generally known) and vanadium tubes to extremely fine tolerances, is believed to be the first instance of these metals being fabricated in other than experimental quantities.

Miscellanea

INSTITUTE OF WOOD SCIENCE.—The Institute of Wood Science, a body just formed to advance the study of wood, held its first annual general meeting on September 25th, when Mr. E. B. Latham was elected president. The Institute states that it already has a membership of 300. It has published a booklet setting forth its aims, and the conditions of membership. The Institute's address is 21, College Hill, London, E.C.4.

OIL SEAL FACTORY.—A new works has been opened for the manufacture of fluid sealing units by George Angus and Co., Ltd., at Wallsend-on-Tyne. The whole of the manufacturing capacity of this firm's oil seal division has been moved to the new works from the Walker works. The new works is built on a 19-acre site and the buildings covering an area of 250,000 square feet include, besides the production shops, offices, research and welfare accommodation.

FUEL OIL CALCULATOR.—The Fuel Oil Technical Department of Fina Petroleum Products, Ltd., has produced a fuel calculator which is designed to enable those concerned with the use of fuels to calculate rapidly the relative cost of various fuels, due allowance being made for relative thermal efficiency. The calculator consists of a body, marked with price and calorific value scales for various fuels, a slide marked with an efficiency adjustment scale and a cursor.

CIVIL ENGINEERING LECTURE COURSES.—The Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1, has compiled a "lecture list" in which details of advanced courses of lectures in various civil engineering subjects are given. The lecture courses listed have been arranged by various universities, technical colleges and bodies such as the Road Research Laboratory, and are grouped geographically; they cover subjects such as shell roof design, concrete technology, soil mechanics, and highway engineering.

TREATMENT OF TRADE WASTES.—The University of Durham Department of Civil Engineering is to hold a residential course, from April 1 to 12, 1957, on "The Treatment of Trade Wastes and the Prevention of River Pollution." The course is being designed to meet the needs of those in industry who have to deal with the problem of liquid effluent disposal, as well as the needs of officers of local authorities and river boards. Full particulars of the course may be obtained from Mr. P. C. G. Isaac, Department of Civil Engineering, King's College Newcastle upon Tyne.

CORROSION PROTECTION FOR SPRINGS.—Crane Packing, Ltd., Slough, Bucks, has now developed a process of coating coil springs in polytetrafluoroethylene, thus rendering them immune from chemical attack, except by fluorine and molten sodium. Such springs are also self-lubricating and nothing will adhere to them. Dispersion coatings of "Fluon" have been applied to utensils in the food industry, so that products that have set can be removed without difficulty. These coatings are obtained by applying to any article a liquid consisting of very small particles of p.t.f.e. resin suspended in water.

OBITUARY.—We record with regret the death of Mr. D'Alton Corry Coleman, which occurred in Montreal, on October 17th, after a long illness. Mr. Coleman, who was seventy-seven, was a former president and chairman of the Canadian Pacific Railway. He began his career with the C.P.R. as an engineer's clerk in 1899, and retired from the presidency in 1947. We also note with regret the death of Mr. O. M. Proudlock-Dunbar, which occurred at Royston, Herts, on October 14th, at the age of seventy-three. Mr. Proudlock-Dunbar was formerly works director of the Brimsdown works of The Ruberoid Company, Ltd.

SILICONE BARRIER PREPARATION.—Lloyd-Hamol, Ltd., Batley, Yorkshire, has produced a silicone barrier preparation "Syl," designed to protect the skin from attack from chemical irritants while allowing it to breathe. Last week the company demonstrated the effectiveness of the preparation by a series of tests. These included a paint-removal test, showing that paint could be peeled off the treated skin; an acid decolorisation test showing that acid could penetrate the preparation; an acid protection test, hydrochloric acid being used; a test designed to show ease of removal of dirt from the treated skin, and fluoresceini removal test to demonstrate that "Syl" is impermeable to water.

PORTUGUESE CIVIL ENGINEERING STUDIES.—We have received from the Laboratorio Nacional de Engenharia Civil, Lisbon, Portugal, a set of a dozen technical reports describing recent work undertaken there. Three of the reports are in English and are reprints of papers submitted to the Fifth Congress on Large Dams, held in Paris last year; they deal with model tests, observations on completed dams, and deformability of rock foundations. The remaining reports, in Portuguese, deal with soil mechanics investigations, non-destructive testing and timber construction. There is also a booklet written in English by Manuel Rocha, the Laboratory's director, setting out its organisation and management.

TUBES AND TUBULAR PRODUCTS.—The very useful publication, *Practice and Specification*, published by Accles and Pollock, Ltd., Oldbury, Birmingham, for the information and assistance of tube users has now been revised and enlarged and issued under the new title *Tube Manufacturing Practice and Specifications*. Its contents include sections on the firm's range of products; tolerances; notes on manufacturing practice; analyses and properties of carbon, alloy and creep-resisting steels; British and American specifications for tubes for various purposes; notes on stainless steel; technical data on non-ferrous metals; the relative corrodibility of metals; properties of carbon steel tubes; tapering rolls and engineers' tables.

B.B.C. REITH LECTURES.—The British Broadcasting Corporation has announced that this year's Reith Lectures are to be given by Sir Edward Appleton, F.R.S., Nobel Laureate, Principal and Vice-Chancellor of the University of Edinburgh. The lectures, entitled "Science and the Nation," will be broadcast in the Home Service on six Sundays, starting on November 11th. In his opening talk, Sir Edward will discuss the present position of science as it affects everyone from the factory worker to the research scientist; in the second lecture, he is to deal with the lessons of the war in its relation to science; in the third he will discuss science for its own sake; in the fourth, science for a purpose; in the fifth, science in industry, and in the sixth and last lecture, science and education, commenting on the training of scientists for the future needs of the nation.

INSTITUTION OF NAVAL ARCHITECTS.—Two papers have been published by the Institution of Naval Architects for written discussion, namely, "The Effect of Model and Tank Size in Two Series of Resistance Tests," by Dr. G. Hughes and "The Rolling and Pitching of a Ship at Sea, a Direct Comparison Between Calculated and Recorded Motions of a Ship in Sea Waves," by Mr. D. E. Cartwright, and Mr. L. J. Rydill. In the first paper the effect of model and tank size in resistance results is discussed in general terms and a method is developed for determining viscous and blockage effects in resistance tests of a series of geometrically similar models carried out in several tanks. The method is applied to two series of tests, one for a fast steamer and one for a cruiser, made at the Hamburg Model Experiment Establishment and supplemented by work at the National Physical Laboratory. In paper number two an analysis is made of the relation between the rolling and pitching of a ship (R.R.S. "Discovery II") at sea and the waves recorded simultaneously by a wave recorder. The ship steamed at 6½ knots on twelve courses in a long-crested wave system, but good results were obtained with the ship head-on to short-crested waves. The method is based primarily on spectral analysis by means of an automatic Fourier analyser, but an important extension is made to show the connection between the spectra of ship motions and their statistical properties. The practical results are compared with theoretical relations derived by methods which ignore certain effects, but are simple to apply, and advanced methods which estimate some terms with greater precision but require greater computational labour. Attention is drawn to the fact that all measurements at sea are subject to statistical errors which can only be reduced by longer recording time.

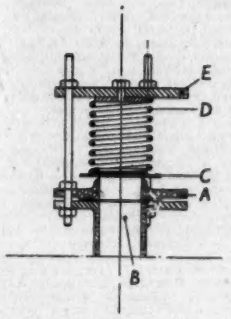
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

HYDRAULIC MACHINERY

757,692. March 11, 1952.—REGULATING THROTTLE DEVICES FOR USE IN HYDRAULIC INSTALLATIONS, Etablissements Neyrpic, Avenue de Beauvert, Grenoble, Isere, France. (*Inventor: Yves Marie Ponsar.*)

The object of the invention is to provide a self-centring throttling device for use in hydraulic systems, for arrangement in front of an orifice delivering a liquid jet in an initially vertical direction. The drawing illustrates a device according to the invention used as a safety device for a conduit in a hydraulic system in which pressure surges are liable to occur. The device includes a flanged nozzle *A* secured to a pipe branching off from the conduit (not shown). The nozzle outlet *B* is sealed by a throttle disc *C* of stainless metal. A spring *D* of calculated



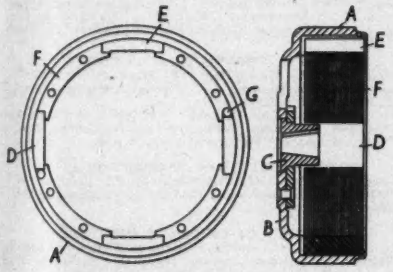
No. 757,692

strength and resilience is disposed with a strong initial compression between the disc and a plate *E* mounted by bolts on the flange of the nozzle. The spring both tightens the disc on the nozzle and allows its self-centring relative to it. By screwing the nuts on bolts, against which the plate *E* bears, up or down the plate can be adjusted within a sufficiently wide range to allow accurate adjustment, when necessary, of the force exerted by the spring in opposition to the hydraulic thrust. As a pressure surge occurs the disc, throughout the period of discharge of liquid from the nozzle, literally floats on the jet and the self-centring effect contributes to its stability.—*September* 26, 1956.

ELECTRICAL ENGINEERING

757,371. May 11, 1954.—MAGNETO ELECTRIC CURRENT GENERATORS, Joseph Lucas (Industries), Ltd., Great King Street, Birmingham, 19. (*Inventor: Albert William Winkley.*)

The invention relates to magneto designed electric current generators to be mounted on, or serve as, the flywheel of a small internal combustion engine, and required to provide current for a spark-ignition coil and/or lighting or other apparatus, particularly on a bicycle. The object of the invention is to enable the permanent magnets and associated pole



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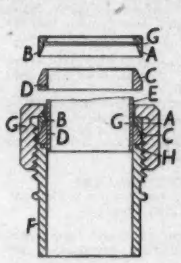
pieces to be combined within a hollow cylindrical rotary housing, in a simple and convenient manner. Referring to the drawing, the housing which serves also as a flywheel, consists of a cylindrical flange *A* extending from one side of a web *B*, and on the centre of the web is formed or secured an inwardly extending boss *C* for attachment to a driving shaft. Also at each of two diametrically opposite positions there is formed on or secured to the inner periphery of the flange a salient abutment *D*. The magnetic field of the generator is provided by a pair of permanent magnets *E* in the form of short, flat bars situated centrally between the abutments *D* and adjacent the flange *A*. In the spaces between the magnets and the abutments are laminated pole pieces *F* in contact with the flange. One end of each of two of the pole pieces adjacent to the abutments is recessed to accommodate a cotter. The cotters may each consist of a slightly tapered solid pin, a longitudinally split spring-steel tube as *G*, or a helical spring. When driven into position the cotters hold the pole piece and magnet assembly securely within the housing. In addition, the free edge of the flange *A* of the housing may be rolled over into contact with the magnets and pole pieces. The number of magnets and pole pieces may be varied to suit different requirements. Also the housing may, alternatively, be adapted to be secured to one side of a separately formed flywheel.—*September* 19, 1956.

TUBE AND PIPE COUPLINGS

757,224. October 29, 1953.—PIPE COUPLINGS, United Gas Industries, Ltd., 51, Lincoln's Inn Fields, London, W.C.2. (*Inventor: Walter Edward Fishwick.*)

The invention relates to couplings for pipes of different external diameters. The couplings are designed especially for use in connection with low pressure gas and air systems. As shown in the drawing, the coupling comprises a brass top or cover ring *A* which has a taper bore *B* and a lead or composition compression ring *C* which has a cylindrical bore or internal diameter *D* only slightly larger than the external diameter of a pipe *E* to be coupled to a pipe *F* by means of a tubular union nut *G* through which nut the pipe *E* is caused to be gripped frictionally. The outside diameter of the compression ring *C* is tapered to coincide with the taper *B* of the bore of the cover ring. In the core of this ring there is a small groove *G* into which the compression ring *C* is forced when the union nut, which has a clearance in respect to the outside diameter of the pipe *E*, is tightened on to the ring *B*. At the same time the base of the ring *C* is pressed on to the end of the pipe *F* and into a groove *H* in its end to form a gas-tight joint there. The pressure also causes the compression ring *C* to be forced inwards against the pipe *E*, thus holding and forming a gas-tight connection on the pipe.—*September* 19, 1956.



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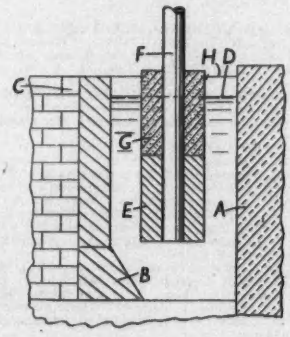
METALLURGY

758,193. May 5, 1953.—HEAT PRODUCING MIXTURES IN CASTING PROCESSES, Foundry Services, Ltd., Long Acre, Nechells, Birmingham, 7. (*Inventor: Kossy Strauss.*)

The invention concerns improvements relating to heat producing mixtures described in Specification No. 627,678. The object being to provide a heat producing mixture for insertion in the molten metal in such a form as will ensure that the metal remains molten for the time desired. Referring to the drawing, a feeder head is formed as an aperture between a sand core *A* and refractory blocks *B* lining the inside surface of refractory brickwork *C*. Molten metal is



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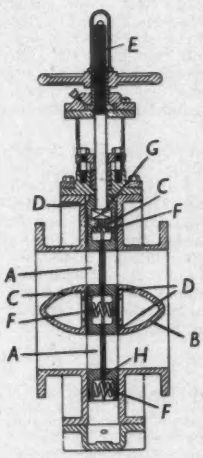
poured through the feeding head so as to have an initial level, as shown at *D*, and a block of heat producing material is then immersed into the metal in the feeding head as the metal begins to solidify. The heat producing material is provided in the form of a cylindrical mass *E* compacted around the lower end of a pipe *F* of steel. In the drawing, which is approximately to scale, the pipe has an external diameter of 2in and the heat producing mass *E* is 6in diameter by 8in long. A porous refractory material compacted around the pipe above the heat producing mass is in the form of a cylinder *G* of bonded sand. The pipe *F* is lowered into the molten metal so that the heat producing mass *E* is completely immersed, the upper part of the bonded sand mass *G* partly protruding above the surface of the metal, which rises to about the level or the top of the feeding head, as at *H*. The refractory material serves to diminish atmospheric loss of heat from the heat producing mass and assists venting. The pipe and the heat producing and refractory masses are located and maintained in the required position by an open-ended shaft above. The heat producing mass is lowered into the metal gradually so as to avoid undue turbulence. It is possible to use two or more masses of heat producing material successively by lifting a consumed mass by its pipe up through the shaft and lowering a new one into position. The refractory mass *G* may be dispensed with and in this case the upper end of the heat producing mass is preferably arranged to protrude slightly above the surface of the molten metal.—*October* 3, 1956.

VALVES

758,086. March 16, 1953.—GATE VALVES, W. C. Holmes and Co., Ltd., Whitestone Ironworks, Huddersfield. (*Inventor: Clement Ingham.*)

The invention relates to gate valves more especially for controlling the flow of gas in gasworks, but may have other applications particularly in the case of valves of larger size. As shown in the drawing, the body of the valve is arranged with twin rectangular ports *A*, each having a length equal to the nominal bore of the valve and width approximately equal to one-third the nominal bore. The cross section of the bore of the valve progressively changes from a circle to a square, having a side equal to the diameter of the circle and progressively changes again to a circle having the same diameter at the other end. Across the centre of the rectangular section is arranged a seating *B* formed in two parts having a maximum width equal to approximately one-third of the side of the square. Thus the free area for gas flow through the two ports is equal to $\frac{2}{3}$, D^2, whereas the area of the pipe is approximately equal to $0{\cdot}78\ D^2$. This reduction in area, which is of no practical consequence, enables the valve to retain a flat surface along the base of the bore, in line with the base of the pipe, whether the valve is in the vertical or horizontal position, thus avoiding either an interruption in the flow of condensate or a cavity in which condensate may collect. Dividing the gas flow into two separate streams enables the body height to be kept within or at the same dimension of valves of other types now generally employed, without causing undue interruption in the gas flow. The two slides *C* which form the gate of the valve and slide in between the two parts of the seating *B*, are each provided with seats *D* corresponding in size to the seats provided on the gas ports, and by virtue of the twin ports the travel of the gate between the full open and full shut positions is reduced to approximately one-third of the bore diameter, thus reducing the size of the valve body and the travel of the spindle *E*, effecting a reduction in the overall height of the valve. In cases of automatic control, particularly when hydraulic equipment is employed, the dimensions of the hydraulic gear are considerably less than in the case of a valve having a travel equal to the bore of the valve, with a consequent saving in space. The two slides *C* are maintained in close contact with the faces provided on the body and seating *B* by means of compression springs *F*, and the slides are maintained in relationship to one another by means of the collar *G* provided on the spindle. Between the rear faces of the slides a sealing joint *H* is employed and this may be of various forms, e.g. a flat joint compressed between ribbed surfaces forming a labyrinth, or the joint may be accommodated in suitable recesses. The joint forms an unbroken seal surrounding each gas port and prevents the entry of liquor into the valve body or the escape of oil (provided to lubricate the working faces of the valve and to prevent the leakage of gas across the two faces of the valve) from the body into the gas main.—*September* 26, 1956.



No. 758,086

Launches and Trial Trips

NICOLAI BURDENKO, cargo ship; built by the Chantiers Navals de la Ciotat for Sudoimport; length overall 425ft 5½in., length between perpendiculars 395ft 8in, breadth moulded 55ft 1½in., depth to upper deck 33ft 2in, draught loaded 22ft 4in, deadweight 6170 tons; service speed 13 knots; two complete decks, four holds, bale capacity 318,000 cubic feet, one 60-ton, one 40-ton, four 10-ton and four 5-ton derricks, electric winches; one set of Rateau-Bretagne geared turbines, 4500 h.p. at 120 propeller r.p.m., two oil-fired water-tube boilers supply steam at 455 lb per square inch and 750 deg. Fah. Trial, September.

OISEAU DES ILES II, passenger and cargo ship; built by the Chantiers Navals de la Pallia for the Compagnie Francaise des Phosphates de l'Oceanie; length between perpendiculars 159ft 1½in., breadth moulded 29ft 2½in, depth 14ft 3½in, draught 13ft 1½in, deadweight 200 tons, gross tonnage 200; twelve cabin passengers, fifty deck passengers; speed 13 knots, one Ruston diesel engine, 890 h.p. at 430 r.p.m. Trial, September.

VITA SISH, coaster; built by the Chantiers Duchesne et Bossiere for Lars-Bakkevig, Norway; length overall 152ft 7in, length between perpendiculars 134ft 10in, breadth moulded 26ft 11in, depth 17ft 2in, draught 10ft 10in, deadweight 520 tons; MAK. MAV. 425 diesel engine, 480 h.p. Trial, September.

KORANUI, cargo liner; built by Alexander Stephen and Sons, Ltd., for the Union Steam Ship Company of New Zealand, Ltd.; length 325ft, breadth 50ft, depth 26ft, deadweight 5300 tons; twelve derricks and one 25-ton derrick, electric winches; Stephen-Sulzer single-acting diesel engines, six cylinders, 600mm diameter by 1040mm stroke, 2410 b.h.p. at 128 r.p.m. and 3000 b.h.p. at 150 r.p.m. overload. Launch, October 3rd.

ANTENOR, cargo and passenger liner; built at the Walker Naval Yard of Vickers-Armstrongs, Ltd., for Alfred Holt and Co.; length overall 491ft 6in, breadth moulded 62ft, depth moulded 35ft 3in, draught loaded 28ft, deadweight 9000 tons; six cargo holds; Kincaid-B. and W. six-cylinder, supercharged diesel engine, 8000 b.h.p. Launch, October 4th.

CANADIAN STAR, cargo and passenger liner; built by the Caledon Shipbuilding and Engineering Company, Ltd., for the Blue Star Line, Ltd.; length overall 470ft, breadth moulded 63ft, depth moulded to shelter deck 39ft 6in, deadweight 9200 tons in open shelter deck condition, sea speed 15½ knots; twelve passengers; five cargo holds, one 50-ton, six 10-ton and ten 5-ton derricks, electric winches, four 200kW diesel-driven generators; two vertical oil-fired auxiliary boilers; Scott-Doxford oil engine, 8000 b.h.p. Launch, October 5th.

Catalogues and Brochures

A. REYROLLE AND CO., Ltd., Hebburn, County Durham.—A leaflet giving illustration and details of their class "J" switchgear.

COLONIAL DEVELOPMENT CORPORATION, 33, Hill Street, London, W.1.—A booklet describing the processing and the uses of Demerera greenheart timber.

BIRMETALS, Ltd., Woodgate Works, Quinton, Birmingham, 32.—A leaflet of tables of mechanical and physical properties of "Birmites" magnesium alloys.

STURTEVANT ENGINEERING COMPANY, Ltd., Southern House, Cannon Street, London, E.C.4.—Publication No. 7203, a leaflet describing the 6in laboratory type electrostatic mineral separator.

QUICKSET WATER SEALERS, Ltd., 20, Albert Embankment, London, S.E.11.—A leaflet giving details of the Setcrete Betance service, which include waterproofing, flooring, r.c. repairs, cement glaze and building chemicals.

THE GENERAL ELECTRIC COMPANY, LTD., Magnet House, Kingsway, London, W.C.1.—An illustrated booklet describing the world exports of this company and the many uses of its equipment throughout the world.

J. STEAD AND CO., Ltd., Sheffield, 2.—A leaflet illustrating the "Screwmaster" four-in-one combination, an adjustable amber handle containing screwdriver, pricker and a file, the leaflet also shows dual-purpose pincers and combination pliers.

A.E.I. LAMP AND LIGHTING COMPANY, Ltd., Crown House, Aldwych, London, W.C.2.—Several catalogues enclosed in a file, they give full detail and specification of all types of lamps, fluoresecent lighting and industrial lighting. Illustration is given to most of the products catalogued.

A.E.I. LAMP AND LIGHTING COMPANY, Ltd., issued from Lighting Sales Division Headquarters, 44, Fitzroy Road, London, N.W.1.—An illustrated loose-leaf catalogue of street lighting equipment such as fluorescent, sodium horizontal, mercury horizontal, tungsten filament and vertically operated mercury and sodium columns, control gear and accessories.

W. E. SYKES, Ltd., Staines, Middlesex.—A pamphlet giving information and illustration to features of the high-production hobbing machine. A catalogue of various machine tools, including rotary gear shavers, vertical gear generators, hobbing machines, hobs, cutters and shaving tools. A leaflet giving information about a fine pitch gear shaving machine, model NS.4 H.

THE ENGLISH ELECTRIC COMPANY, Ltd., Publicity Department, Forgate Street Offices, Stafford.—An illustrated catalogue of type OB2 air-break switchgear for service up to 600A at 660V An illustrated catalogue giving description of a range of "English Electric" control boards, data is given about the construction and special features of this equipment. A leaflet showing the application of inverse-time over-current relays. A leaflet giving illustration and details of the "English Electric" condenser bushings which are spring loaded and oil filled.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Wed., Oct. 31st.—BRIGHTON, HOVE AND DISTRICT BRANCH: New Imperial Hotel, First Avenue, Hove, "New Light Sources," G. V. McNeill, 7.30 p.m.——NOTTINGHAM BRANCH: Mechanics Institution, Trinity Square, Nottingham, Film of the 1956 Electrical Engineers' Exhibition, 7.15 p.m.

Thurs., Nov. 1st.—S. LONDON BRANCH: Half Moon Hotel, Broad Green, Croydon, "Power Factor Correction," J. R. Arthur, 8 p.m.

Fri., Nov. 2nd.—LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, "Modern Railway Signalling," J. Sulston, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Oct. 31st.—LONDON SECTION: School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Annual General Meeting. Presidential Address, G. A. Marriott, 6 p.m.——S. WALES SECTION: College of Technology and Commerce, Cathays Park, Cardiff. Annual General Meeting, "Applications of Transistors to Radio Reception," L. E. Jansson, 6.30 p.m.

Thurs., Nov. 1st.—S. MIDLANDS SECTION: Winter Gardens, Malvern, "Principles of the Light Amplifier and Allied Devices," T. B. Tomlinson, 7 p.m.——N.W. SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, "Electronics Applied to Physiology," H. W. Shipton, 6.30 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Nov. 3rd.—Caxton Hall, Caxton Street, London, S.W.1, "The Atmosphere of Mars," R. M. Goody, 6 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, Oct. 26th.—BATH AND BRISTOL CENTRE: S.W. Electricity Board, Bath, "Light and the Eye," Drummond Curry, 7 p.m——BIRMINGHAM CENTRE: "Regent House," St. Phillip's Place, Colmore Row, Birmingham, "Aerodrome Lighting," J. W. Morse, 6 p.m.

Mon., Oct. 29th.—LEEDS CENTRE: Yorkshire Electricity Board Lecture Theatre, Ferensway, Hull, "Problems of Shop and Store Lighting," K. C. White, 7 p.m.

Thurs., Nov. 1st.—GLASGOW CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Design To-day," A. Maynard, 6.30 p.m.——NOTTINGHAM CENTRE: Electricity Service Centre, Smithy Row, Nottingham, "Road Vehicle Lighting," J. H. Nelson, 5.30 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Oct. 29th.—W. AND E. YORKSHIRE BRANCH: The University, Leeds, "Commonsense Fuel Economy," C. W. Peters, 7.30 p.m.

Fri., Nov. 2nd.—PETERBOROUGH BRANCH: White Lion Hotel, Church Street, Peterborough, "The Development of the B.R.M.," 7.30 p.m.

Tues., Nov. 6th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2, "The Use of Radio Isotopes in Industry," C. W. Jones, 7 p.m.——EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, "Choice of Pumps," 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Sat., Oct. 27th.—BRISTOL AND W. OF ENGLAND BRANCH: Grand Hotel, Broad Street, Bristol, "Some Developments in Foundry Sands Practice," A. Tipper, 3 p.m.

Thurs., Nov. 1st.—STOKE SECTION: Stipendiary Court Room, Hanley, "Core Assembly Methods," E. H. Beech, 7.30 p.m.

Mon., Nov. 5th.—LANCASHIRE BRANCH: Midland Hotel, Manchester, "Fast Drying Bonding Materials," A. I. Donaldson, 7 p.m.——SHEFFIELD BRANCH: College of Commerce and Technology, Department of Engineering, Pond Street, Sheffield, 1, "Training," O. W. Reynolds; "Foundry Training," H. Parkin, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Wed., Oct. 31st.—JUNIOR LECTURE: Poplar Technical College, London, E.14, "Modern Marine Steam Turbines," J. H. Gooch, 7.15 p.m.——MERSEYSIDE AND N.W. SECTION JUNIOR LECTURE: Riversdale Technical College, Liverpool, "Boiler Water Treatment," J. D. Skelly, 5.30 p.m.

Thurs., Nov. 1st.—JUNIOR LECTURE: West Ham College of Technology, London, E.15, "Metallurgy in Marine Engineering," J. E. Garside, 7 p.m.

Mon., Nov. 5th.—STUDENT MEETING: 85, Minories, London, E.C.3 Films, including "Mail Boat," 6.30 p.m.——MERSEYSIDE AND N.W. SECTION: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "Some Recent Metallurgical Problems in Marine Engineering," B. Todd, 6.30 p.m.

INSTITUTE OF METALS

Thurs., Nov. 1st.—LONDON LOCAL SECTION: Royal School of Mines, South Kensington, London, S.W.7, "Primitive Metallurgy," F. C. Thompson, 7 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Mon., Oct. 29th.—W. MIDLANDS CENTRE: Chamber of Commerce, Birmingham, "The Preparation and Handling of Feeding Stuffs," J. R. Robertson, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., Oct. 31st.—GRADUATES AND STUDENTS' SECTION: Whole-day Visit to Shellhaven Refinery, Stanford-le-Hope, Essex.

INSTITUTION OF CIVIL ENGINEERS

Tues., Oct. 30th.—HYDRAULICS MEETING: Great George Street, Westminster, London, S.W.1, Symposium on Side Spillways, General Reporter P. O. Wolf; "A Theoretical Consideration of Side Weirs as Storm Overflows," Peter Ackers; "The Discharge of Water Over Side Weirs in Circular Pipe," J. W. Allen; "The Discharge Capacity of Side Weirs," V. K. Collinge; "The Behaviour of Side Weirs in Prismatic Channels," Wm. Frazer, 5.30 p.m.

Thurs., Nov. 1st.—LECTURE ON THE CONSERVATION OF NATURAL RESOURCES: Great George Street, Westminster, London, S.W.1, "Conservation of Land," L. Dudley Stamp, 5.30 p.m.

Tues., Nov. 6th.—ORDINARY MEETING: Great George Street, Westminster, London, S.W.1, Presidential Address, H. J. F. Gourley, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon. to Fri., Oct. 29th to Nov. 2nd—RADIO AND MEASUREMENT SECTION: Savoy Place, London, W.C.2. Convention on Ferrites.

Tues., Oct. 30th.—N. MIDLAND CENTRE: The University, Leeds, Discussion on "The Teaching of High-Voltage Testing," opened by D. A. Jones, 6.30 p.m.

Wed., Oct. 31st.—S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Age and the Incidence of Fires in Electrical Installations," L. Gosland, 7 p.m.

Tues., Nov. 6th.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, "Electric Strength of Highly Compressed Gases," E. H. Holt; "Insulated Properties of Compressed Electro-Negative Gases," P. R. Howard, 5.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Nov. 5th.—N.E. BRANCH: Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, 6, "The Design and Application of Centrifugal Pumps," D. W. Coleman, 7.15 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Nov. 6th.—39, Elmbank Crescent, Glasgow, "The Operation of an Oil Refinery," J. G. Annan, 6.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Tues., Oct. 30th.—SCOTTISH BRANCH: Building Centre, 425, Sauchiehall Street, Glasgow, C.2, "Medium Pressure Hot Water," T. H. F. Holman, 7 p.m.

Wed., Oct. 31st.—E. MIDLAND BRANCH: College of Arts and Crafts, Waverley Street, Nottingham, "The Practical Application of Air Conditioning in Industry," L. G. W. Gosden, 7.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Wed., Oct. 31st.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Some Problems in the Manufacture of Coated Macadam," R. Y. Parkinson, 6 p.m.

Fri., Nov. 2nd.—N.E. BRANCH: King's College, Newcastle upon Tyne, "Modern Vehicle-Actuated Road Signals," F. V. Webster, 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Oct. 26th.—GENERAL MEETING IN CONJUNCTION WITH THE APPLIED MECHANICS AND LUBRICATION GROUPS: 1, Birdcage Walk, Westminster, London, S.W.1, "Principles and Applications of Hydro-dynamic Type Gas Bearings," G. W. K. Ford, D. M. Harris and D. Pantall, 6 p.m.

Tues., Oct. 30th.—BIRMINGHAM A.D. CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Proof Testing of Electrical Equipment," 6.30 p.m.——WESTERN A.D. CENTRE: Royal Hotel, Bristol, Chairman's Address, 6.45 p.m.——YORKSHIRE GRADUATES' SECTION: Visit to A. Lee and Sons, Ltd., Steel Works, Sheffield, 6 p.m.

Wed., Oct. 31st.—INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP AND EDUCATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion, "Selection and Training of Engineering Designers," 6.45 p.m.——E. MIDLANDS BRANCH: College of Art and Crafts, Waverley Street, Nottingham, "The Practical Applications of Air Conditioning in Industry," L. G. W. Gosden, 7.30 p.m.——SOUTHERN BRANCH: Technical College, Reading, "The Dimensioning of Engineering Drawings," W. Abbott, 7 p.m.

Thurs., Nov. 1st.—EASTERN BRANCH: Dujon Restaurant, Bedford, "A Review of Freight Aircraft," B. P. Laight, 7.30 p.m.——N.W. BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "A Criticism of the Technical Education of Recently Qualified Engineers," P. P. Love, 6 p.m.——SCOTTISH BRANCH: Technical College, George Street, Glasgow, "Nuclear Pressurised Water Reactors," J. M. Kay and F. J. Hutchinson, 7.30 p.m.

Fri., Nov. 2nd.—GENERAL MEETING IN CONJUNCTION WITH THE INTERNAL COMBUSTION ENGINE GROUP: "A Review of the Performance of Exhaust Systems for Gas Turbine Aero-Engines," P. F. Ashwood, 6 p.m.——SCOTTISH BRANCH: Robert Gordon's College, Aberdeen, "Nuclear Pressurised Water Reactors," J. M. Kay and F. J. Hutchinson, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Oct. 26th.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, Chairman's Address, R. J. Fowler, 6 p.m.

Thurs., Nov. 1st.—S.W. COUNTIES BRANCH: Duke of Cornwall Hotel, Plymouth, Chairman's Address, R. Hazzledine, 7 p.m.

Fri., Nov. 2nd.—W. COUNTIES BRANCH: New Engineering School, University of Bristol, "The Results of Experiments on Torsion in Concrete and Their Application to Design," S. Armstrong, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Oct. 26th.—ORDINARY MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Rubber and the Process of Manufacture," F. Skelton, 7 p.m.

Fri., Nov. 2nd.—FILM EVENING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Man with a Thousand Hands" and "On a New Track." 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Oct. 26th.—Engineers' Club, Albert Square, Manchester, "John Rennie, 1761–1821, a Study of the Life and Work of an Engineer in Georgian England," C. T. G. Boucher, 6.45 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Nov. 2nd.—PARSONS MEMORIAL LECTURE: Literary and Philosophical Society, Newcastle upon Tyne, "A Review of Naval Propulsion Engineering Progress in the Last Ten Years," Sir Frank T. Mason, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Nov. 6th—N.W. BRANCH: College of Technology, Sackville Street, Manchester, "Methods of Shuttering as They Affect the Design and Surface Finish of Concrete," C. Parry, 6.45 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Oct. 30th.—GRADUATES' AND STUDENTS' SECTION: 4, Hamilton Place, London, W.1, "Nuclear Power for Aircraft," E. P. Hawthorne, 7.30 p.m.

Tues., Nov. 6th.—MAIN LECTURE: Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "London Airport," Sir John D'Albiac, 6 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN

To-day, Oct. 26th.—21, Albemarle Street, London, W.1, "Diamonds, Meteorites and the Origin of the Solar System" Harold C. Urey, 9 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Mon., Nov. 5th.—CORROSION GROUP: Chemistry Lecture Theatre, The University, Leeds, "The Stress Corrosion of Steel in Caustic Soda Solutions," F. A. Champion, 7 p.m.

SOCIETY OF ENGINEERS

Mon., Nov. 5th.—ORDINARY MEETING: Geological Society, Burlington House, Piccadilly, London, W.1, "Gas Turbines in Theory and Practice," D. F. Collins, 5.30 p.m.

SOCIETY OF INDUSTRIAL RADIOLOGY

To-day, Oct. 26th.—British Institute of Radiology, 32, Welbeck Street, W.1, "Welding and Inspection of High-Pressure Pipes," J. H. Webborn, 7 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Oct. 30th.—JOINT MEETING WITH CONTROL SECTION: Manson House, Portland Place, London, W.1, "Control Engineering and the Automatic Process Plant," D. S. Townend, 6.30 p.m.